Balloon Litter on Virginia's Remote Beaches

Results of Monitoring from 2013 through 2017

A report from Clean Virginia Waterways of Longwood University to the Virginia Coastal Zone Management Program for the FY16 Task 94.03 Grant

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Virginia Coastal Zone MANAGEMENT PROGRAM

NOAA
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This is an accumulative report of all data collected as part of the FY16 grant to Clean Virginia Waterways of Longwood University from the Virginia Coastal Zone Management Program at the Virginia Department of Environmental Quality through grants from the Office for Coastal Management at NOAA, under the Coastal Zone Management Act of 1972, as amended. This report includes data that were collected under two previous Virginia Coastal Zone Management Program grants: FY14, Task 95.03 and FY15, Task 95.03. This report also includes data collected in 2013 and 2014 prior to funding support from the Virginia Coastal Zone Management Program. Additional support for this research came from Clean Virginia Waterways of Longwood University and in-kind contributions from many partners. The views expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Department of Commerce, NOAA, or any of its sub-agencies.

One intent of this research is to help measure/evaluate the effectiveness of the Community-Based Social Marketing research to decrease the intentional mass release of balloons. This research, undertaken by the Virginia Coastal Zone Management Program, Clean Virginia Waterways and several other partners, resulted in the *"Joyful Send-off"* campaign. We encourage readers to visit JoyfulSendoff.org to learn more about this campaign.

All photos by Christina Trapani unless otherwise noted.
Cover photo top row: Wendy Walton
Bottom row: Christina Trapani

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INTRODUCTION

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Marine Debris

Balloon litter in the marine environment is a type of marine debris. Marine debris is any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally disposed of or abandoned into the marine environment or Great Lakes (NOAA, 2018a). It includes items made from plastics, metal, glass, paper, wood, rubber and other biodegradable and non-biodegradable materials (Figure 1). Once trash is transported into rivers and coastal waters through storm drains, it becomes known as marine debris. According to the National Marine Debris Monitoring Program, as much as 80% of marine debris found on U.S. beaches comes from land-based sources (Sheavly, 2007).

Figure 1: Marine debris on a remote beach on Virginia's eastern shore.

The negative impacts of marine debris on wildlife have been well documented. More than 260 species of birds, turtles, marine mammals, crustaceans, and fish have been reported as entangled in marine debris, or have ingested it (Kershaw, Katsuhiko, Lee, Samseth, Woodring & Smith, 2011). While entanglement in debris can cause animals to be immobilized, strangled, or drowned, ingestion of debris items can also lead to death by damage and/or obstruction to the gut and other complications (Kershaw et al., 2011).

Balloons: A Different Kind of Litter

Figure 2: A balloon release is held in honor of breast cancer patients and survivors. Photo by Ralph Barrera/American-Statesman.

Mass quantities of helium-filled balloons are littered each year by businesses, nonprofit groups, schools, and individuals when they are released into the environment. These balloons are often released into the sky as part of celebrations like sporting events, weddings, graduations and political rallies, as well as memorials and funerals (Figure 2).

Balloons are also purchased in smaller quantities by individuals for special occasions, decorations, and gifts. Frequently balloons are handed out at events, stores, restaurants and other venues. While the original intention may have not been to release them, accidents often happen, and once released, these balloons also result in litter.

Figure 3: This bunch of balloons originated in Saugerties, New York, approximately 375 miles from where they were found on the beach of False Cape State Park in Virginia.

Balloon Litter Travels

Balloons are unique in their ability to travel vast distances. For example, a balloon released during the opening ceremony of the Olympic Games in Nagano, Japan on February 7, 1998 was found a mere 49 hours later in Los Angeles, California (Ecolovy, 2017). It was calculated that this balloon traveled 5,300 miles at an average of more than 100 miles per hour. In 2006, a beach cleanup volunteer in Virginia found a balloon with an attached note indicating that the balloon had been released in Oklahoma, more than 1,300 miles away (J. Chubb, personal communication, November 15, 2006). More recently, in February, 2018, during a marine debris survey in Hampton, Virginia, an imprinted latex balloon with a plastic ribbon was found along the shoreline of the Chesapeake Bay. If this balloon was actually released in Kansas, it had traveled almost 1,400 miles. (C. Trapani, personal communication, February 10, 2018). Consequently, the negative impacts of balloon litter can occur great distances from their point of release.

The amount of time helium-filled balloons remain suspended in the air varies based on several factors including material, size, treatments, inflation, altitude and atmospheric conditions including temperature (Balloon Saloon, 2018; Balloon Time, 2018). We assume that these suspension times can have an effect on how far balloons travel. According to one event planner who supplies balloons, helium-filled foil balloons can “float” for two weeks or more if properly inflated and sealed. Latex balloons tend to be more porous and float for shorter amounts of time (1-2 days). Larger latex balloons may float for three days. If latex balloons are treated with a chemical that seals the balloons, they may float for three days or more. Temperature affects these times, as heat may cause balloons to pop within an hour, and cool environments cause helium molecules to shrink, thus reducing the size and float time of balloons (Balloon Saloon, 2018).

Balloon Litter in the Marine Environment

Several factors may affect the distribution of balloons in the marine environment. Since prevailing wind patterns over the continental United States are generally from the west to the east (NOAA, 2011), one would expect most helium-filled balloons to float towards the east. This, in combination with findings that helium-filled balloons can travel long distances in the atmosphere, suggests that balloons released in the continental United States will travel east toward the Atlantic coastline.

Figure 4: This bunch of balloons was found floating approximately 3 miles off the coast of Virginia Beach during a whale research trip.

Increasing the likelihood of balloon findings in marine areas is the percentage of water on the Earth's surface. Since more than 70% of Earth's surface is covered by water, balloons returning to Earth may have a higher possibility of landing on water (Figure 4).

Once they enter the marine environment, even deflated and burst balloons can float at or near the surface of marine waters. Burst latex balloons have been reported to float in salt water for at least 2 weeks (Foley, 1990). Buoyant balloons are subject to the same hydrodynamic mechanisms responsible for the movement, aggregations, and endpoints as natural flotsam such as pelagic Sargassum and other marine algae (O'Shea, Hamann, Smith & Taylor, 2014). These aggregations of floating balloons and other plastic trash along with natural debris increases the likelihood of their interactions with marine wildlife such as juvenile sea turtles (Witherington, Hirama & Hardy, 2012).

Types of Balloons

For purposes of this study, balloons have been categorized into three main types: latex, foil and weather balloons (Figure 5). Latex balloons are made with the sap from a rubber tree. During the manufacturing process many chemicals are added to raw rubber including pigments, oils, curing agents and accelerators (Balloon Headquarters, 2017). While natural latex balloons are considered biodegradable by some (Balloon Council, 2018a), it has been argued that latex balloons may take several months to several years to biodegrade (Balloons Blow, 2018a; Foley, 1990).

Foil balloons are often incorrectly referred to as Mylar balloons ("Mylar" is actually a brand name for a special type of polyester film). Foil or metallic balloons are made of plastic (nylon) sheets coated with polyethylene and metallic materials that are sealed together with heat (The Pop Shop, 2017). Our experience shows that these metallic inks and paints flake off when exposed to environmental factors,

Figure 5: From left to right, latex balloon (Photo by A Bella Mia Flowers), foil balloon (Photo by Balloons & More), weather balloon (Photo by NOAA).

leaving a clear plastic balloon. While these paints could pose environmental hazards, we are not aware of any studies on this aspect of the balloon litter problem. Over time, foil balloons break up into smaller pieces (C. Trapani, K. O'Hara, personal observation) but are not biodegradable (Balloon Council, 2018a).

Weather balloons are used to collect atmospheric data. These balloons are made of latex and are attached to an instrument box called a radiosonde. Filled with helium or hydrogen, weather balloons can expand from 6 to 20 feet across and reach elevations of 20 miles above the Earth's surface (NOAA, 2018b). Weather balloons are known to drift more than 125 miles from their point of release (NOAA, 2018b). Eventually, these balloons burst and fall back to Earth. According to the National Oceanic and Atmospheric Administration's National Weather Service (2018), more than 75,000 helium-filled weather balloons are released each year from 92 sites throughout the United States and its territories. Most of these facilities release two weather balloons per day every day of the year (NOAA, 2018b). While the final deposition of most weather balloons released in the United States seems to be largely unknown, researchers in Australia found that 65% to 70% of weather balloons released into the environment end up in the ocean (O'Shea et al., 2014).

Figure 6: Balloons with plastic ribbon and plastic valve attachments. This group of latex balloons washed up in the wrack line on a beach in Virginia Beach, Virginia. Each balloon had plastic ribbons and white plastic valves attached. Photo by Katie Register.

Balloon Attachments

Helium-filled balloons often have plastic ribbons and other items attached such as plastic valves, tie-off disks, and clips (Figure 6). These attachments are used to

seal the air or helium into the balloon as well as attach ribbons and groups of balloons together. Balloon litter data collected during a two-year study by Clean Virginia Waterways and the Virginia Aquarium & Marine Science Center demonstrated that plastic items including ribbons, valves, tie-off disks, and laminated notes were attached to 58% of balloons found littered in Virginia (Trapani & Register, 2014). It is also not uncommon to find plastic ribbons that have become separated from balloons.

Balloon Litter Harms Marine Wildlife

While all marine debris has some potential to harm wildlife, balloons have been identified as among the five "deadliest" types of debris in terms of the risk they pose to marine wildlife (Figure 7) (Wilcox, Mallos, Leonard, Rodriguez & Hardesty, 2016). Many species of marine wildlife, including the endangered Kemp's ridley (*Lepidochelys kempii*) and leatherback sea turtles (*Dermochelys coriacea*), have been reported to ingest balloons (Mrosovsky, Ryan & James, 2009). It is thought that balloons may resemble prey such as squid and jellyfish (Figure 8) (Mote, 2009; Schuyler, Hardesty, Wilcox, & Townsend, 2012).

Figure 7: The Ocean Conservancy's 5 deadliest items to marine wildlife. (Source: Ocean Conservancy)

Balloon attachments, including plastic ribbons, valves, tie-off disks, and clips, also present a threat of entanglement and ingestion. For instance, in 2014, a critically endangered Kemp's ridley sea turtle (*Lepidochelys kempii*) was found dead on Fisherman Island, Virginia with two latex balloons lodged in its gastrointestinal tract (Figure 9). Protruding from the animal's mouth was a plastic ribbon attached to one of the balloons measuring 44.8 cm in length. The second latex balloon was found lower in the gastrointestinal

Figure 8: A foil balloon (left) next to a beached moon jelly (Aurelia aurita, right) demonstrates the similarities between the two items.

Figure 9: A critically endangered Kemp's ridley sea turtle (Lepidochelys kempii) found stranded dead on Fisherman Island, Virginia with two latex balloons and a plastic ribbon lodged in its GI tract. (Data provided by the Virginia Aquarium Stranding Response Program, 2014). Photo on left by Pam Denmon, U.S. Fish & Wildlife Service Northeast Region, 2014. Photo of the ribbons and intestines of the turtle provided by Virginia Aquarium Stranding Response Program, 2014.

tract. The entire length of the gastrointestinal tract measured an estimated 155.0 cm (Sue Barco, Virginia Aquarium Stranding Response Program, Personal communications, 2014). Figures 10-12 also demonstrate several incidences of wildlife interactions with balloons and their attachments.

Weather balloon equipment has also been reported to cause entanglement in Virginia. Weather balloons include foamed-plastic instrument boxes, radiosonde, parachutes, strings, wires or plastic frames which hold the instrument boxes, and latex or synthetic rubber balloons. For example, in 2009,

Figure 10: Balloon ribbons entangle and kill Virginia's wildlife. A dead laughing gull (Larus atricilla) hangs from a power line entangled in a latex balloon's ribbon. Photo by Pam Denmon, U.S. Fish & Wildlife Service, 2009.

Figure 11: This Cory's shearwater (Calonectris diomedea) was found in 2012 at Back Bay National Wildlife Refuge by Virginia Aquarium Stranding Team volunteers. Its neck, wings and legs were entangled by a plastic balloon ribbon. Photo by Christina Trapani, Virginia Aquarium Stranding Response Program.

Figure 12: In 2004, a leatherback sea turtle (Dermochelys coriacea) stranded alive near Oregon Inlet, NC. Veterinarians made the decision to euthanize the animal. The animal was thin but had no obvious cause of death. When the stomach contents were examined, a large plastic ball was blocking the GI tract, which was likely starving the animal. The plastic piece on the left is a foil balloon. Photos by Matthew Godfrey, NC Wildlife and Nikki Desjardin, Florida Atlantic University.

the Virginia Aquarium Stranding Response Team responded to a deceased Kemp's ridley sea turtle (*Lepidochelys kempii*) on Wreck Island, Virginia, entangled in the strings of a weather balloon (Figure 13) (Virginia Aquarium Stranding Response Program, 2009).

Figure 13: A critically endangered Kemp's ridley sea turtle found entangled in weather balloon string. Photo by Christina Trapani, Virginia Aquarium Stranding Response Program.

Studies suggest that some animals will select balloons over other debris items. A study of marine debris ingestion found that short-tailed shearwaters (*Puffinus tenuirostris*) had consumed hard plastic, rubber, and balloons in quantities that were disproportionately high compared to the amount of these man-made materials in the marine environment (Acampora, Schuyler, Townsend & Hardesty, 2014). Schuyler et al. (2012) found evidence that pelagic sea turtles also show selectivity for balloons. Based on these data, Schuyler et al. (2012) called for measures that would decrease the amount of balloons entering the ocean.

Balloons and Terrestrial Animals

There is further documentation that balloons pose problems for terrestrial animals, including livestock and horses. In addition to threats of entanglement and ingestion, balloons have also been documented to cause animals to panic which may result in injury.

For example, in 2011, a farmer in Kent, UK was awarded compensation after his 13-month old bull choked to death on a balloon released from a nearby primary school (The Telegraph, 2011). Other examples include:

- A colony of flamingos in Carmargue, France was disrupted when a balloon landed in their nesting site. This led to reproductive failure of the colony as it caused the flamingos to abandon their nests (Béchet, Thibault & Boutron, 2017).
- A Facebook post from American Cattlemen showed a photo of a red foil balloon that had been removed from the mouth of a calf. The cattlemen mention that cattle, especially young ones, will eat anything (American Cattlemen, 2017).
- A show horse worth £15,000 died after it swallowed a balloon string, and in a panic, ran through two fences, breaking two legs and its neck (French, 2017).
- An article in Outdoor California describes the issue of balloon ingestion by southern California's bighorn sheep. Bighorn sheep, designated as a fully protected species in California, are often found deceased with latex balloon fragments in their digestive tracts. "We have found everything from small latex fragments to entire balloon bouquets completely impacting the animals' digestive tracts," says Jeff Villepique, a Department of Fish and Game associate wildlife biologist (Figure 14) (Barboza, 2010).

Figure 14: Image of a bighorn sheep skull with evidence of being harmed by balloon ribbon (Outdoor California, 2010).

- A newborn lamb in the UK was found with a balloon and ribbon entangled around its neck and foot. The balloon had traveled more than 40 miles from a Marks & Spencer store. The lamb survived its encounter and the store chain made a commitment to stop the use of promotional balloons (Daily Mail Reporter, 2008).

Figure 15: A photo depicting balloons in power lines, which can lead to power outages. Photo by Katie Register.

Balloons Cause Power Outages

Because of their electrically conductive properties, metallized foil balloons are discouraged for release by the balloon industry and power companies because they can cause electrical outages when they hit power lines (Figure 15). While there is no national collection of data on foil balloons' impacts on power supplies, Clean Virginia Waterways gathered evidence that up to 20% of power outages are caused by balloons making contact with power lines (Witmer, Register & McKay, 2017). In the first eight months of 2015, Dominion Power in Virginia reported 40 balloon-caused power outages, one of which left 14,600 families and businesses without power (Witmer, Register & McKay, 2017).

This risk to power lines instigated a law in California in 1990 that requires foil balloons to be sold with a weight attached, and that metallic ribbons not be used (Balloons Blow, 2018a). In spite of this law, Pacific Gas and Electric (PG&E) stated that metallic balloons caused more than 300 outages in 2013, cutting service to 165,000 homes (Witmer, Register & McKay, 2017). Southern California Edison reported 656 power outages caused by balloons in 2014, and in 2016, metallic balloons caused 429 power outages within PG&E's service area, cutting power to 200,000 homes and businesses (Witmer, Register & McKay, 2017; Woolfolk, 2018). In 2018, two power outages caused by foil balloons made the news: 3,600 residents in San Jose, California lost power when foil balloons floated into power lines causing them to short circuit, and on January 7, 2018, power outages impacted 3,000 customers in Mid-City New Orleans, Louisiana when a foil balloon hit a power line (Cunningham, 2018).

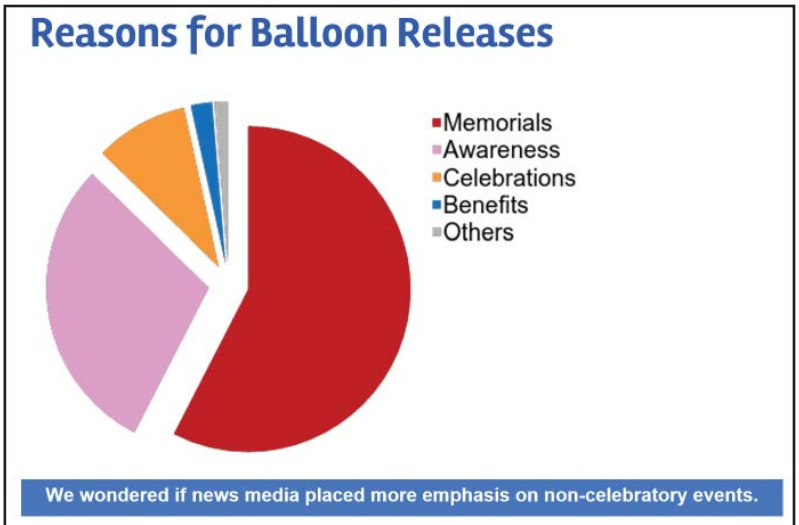
Who Releases Balloon and Why

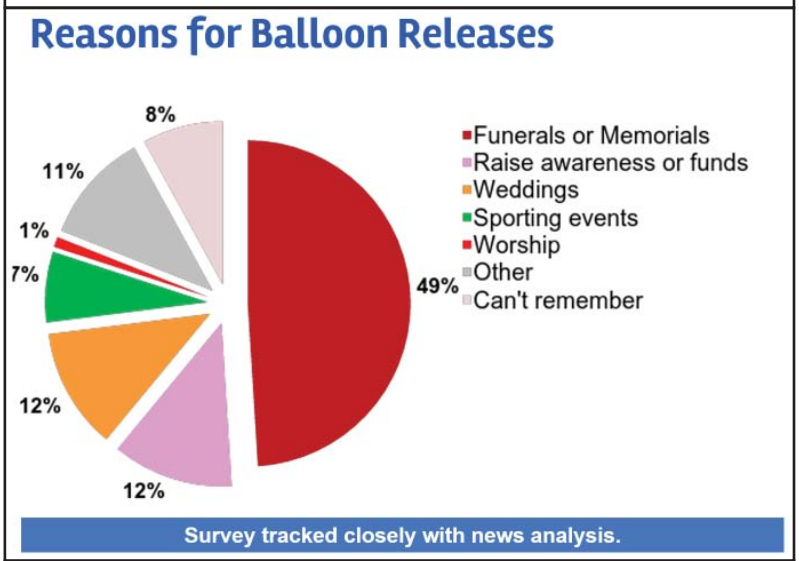
Releasing helium-filled balloons into the air is sometimes accidental, but often it is pre-planned and intentional. For example, balloons given to children at fairs or by restaurants can be released by accident while balloons used as decorations at parties or celebrations may be released at the end of the event instead of being disposed of properly. On the other hand, some sporting events have a tradition of releasing large numbers of helium-filled balloons including Clemson University (Balloons Blow, 2013) and The Indy 500 (Indy 500, 2018). According to multiple-year research done by the Virginia Coastal Zone Management Program and Clean Virginia Waterways, 86% of the people who organize balloon release events in the U.S. are women (Witmer, Register & McKay, 2017). Memorials (especially for

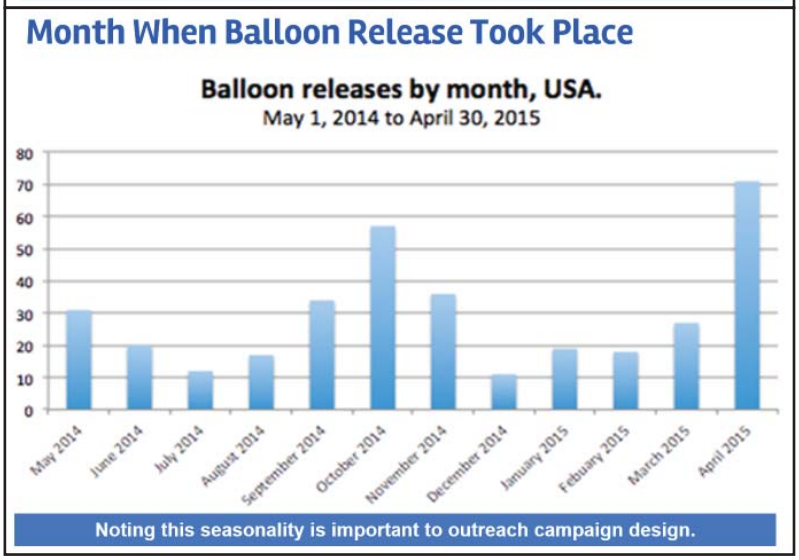
children) are the most popular reason people organize mass balloon releases; events to raise awareness, celebrate, and raise funds for charities are other reasons for balloon releases (Figures 16 & 17) (Witmer, Register & McKay, 2017).

This pioneering research also revealed:

- Many people assume that "biodegradable" means "harmless."
- Some people are aware that released balloons become litter and can have a negative impact on wildlfe, yet they justify or rationalize their actions.
- For a balloon release to illicit strong emotional responses, it must be done as part of a ceremony.
- Most balloon releases are planned and organized by associations, families, schools, community groups, and churches without going through professional event planners.
- Spring has the highest number of balloon releases, followed by the fall (Figure 18).
- Many people do not understand that no balloon is "environmentally friendly," and that every released balloon becomes litter and can be harmful.
- Intentional balloon releases take place mainly in parks, outside of schools, churches and wedding venues.
- Some rural residents think their distance from the ocean makes balloon releases acceptable.







Figures 16-18: An analysis of national media (top) and a survey of Virginians (middle) reveal that the most common reason for intentional balloon releases is memorials. An analysis of national media also reveals that balloon releases are more common in spring and fall (bottom).

- Electrical outages caused by foil balloons contacting power lines is concern to many (Witmer, Register & McKay, 2017).

Efforts to Prevent Balloon Releases Through Behavior Change

Government agencies, businesses, educational institutions, zoos and aquariums, and environmental organizations around the world are working to prevent balloon releases through social marketing campaigns, enforcement of anti-litter laws, policies, and public awareness and education. For example, Balloons Blow, a non-profit organization in Florida, uses a large social media presence to educate the public and works to prevent planned balloon releases. Their website provides extensive information on the hazards posed by balloon litter, legislative efforts, and alternatives to balloon releases such as blowing bubbles, planting trees, creating remembrance gardens, and other environmentally-friendly activities (Balloons Blow, 2018b).

Clean Virginia Waterways has been involved in many balloon litter-related projects, educates the public regarding the dangers of balloon litter and has been compiling data collected by citizen scientists in Virginia on balloon litter through www.virginiaballoonstudy.org as well as through the International Coastal Cleanup.

In an attempt to influence the behavior of brides and grooms as they plan their wedding celebrations, the *Joyful Send-off* campaign was developed by the Virginia Coastal Zone Management Program and its partners (Joyful Send-off, 2018). This campaign, rooted in the principles of Community-Based Social Marketing, "sells" memorable, joyful, picture-perfect and litter-free ideas to engaged couples. In addition to reducing the number of mass releases of balloons at weddings, it is hoped that this Community-Based Social Marketing campaign will, by extension, reduce the number of balloons released at other celebratory/memorial events once brides and grooms learn that all released balloons become litter. The *Joyful Send-off* campaign strategy is a positive one and includes colorful, vivid, and captivating imagery and multi-media, including videos with couples sharing their personal experiences. The strategy also engages and educates venues, event planners, and other wedding businesses, who influence the decisions of couples (Witmer, Register & McKay, 2017).

A limited number of businesses have voluntarily adopted policies against the use of helium-filled balloons for promotional purposes, such as the grocery store chain Trader Joe's which phased out balloons after negative customer feedback (Graff, 2010). The retailer Marks & Spencer stopped using promotional balloons after a lamb was almost killed from becoming entangled in one (Daily

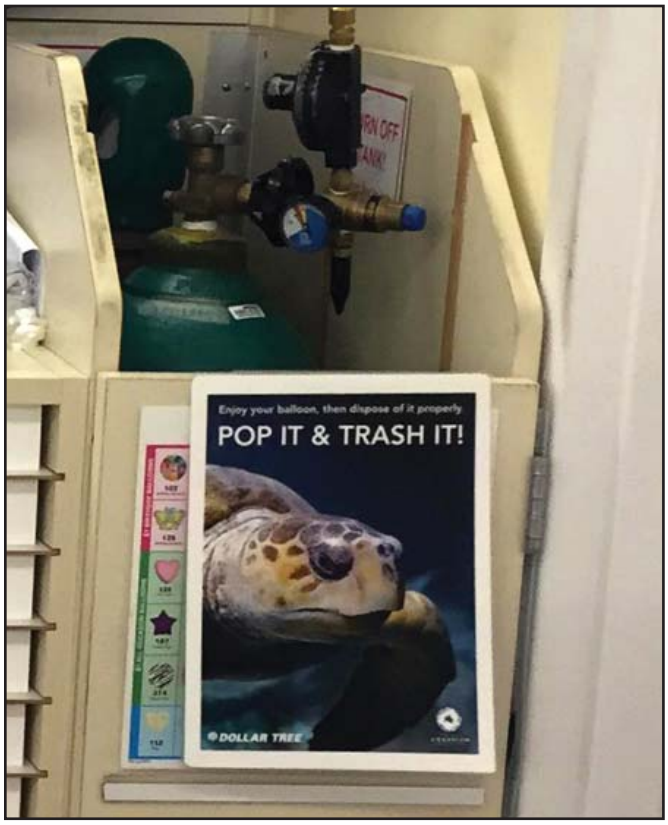


Figure 19: A sign encouraging customers to "Pop it & trash it!" at a Virginia Beach Dollar Tree store. Photo by Kathy O'Hara.

Mail Reporter, 2008). The Virginia Aquarium & Marine Science Center worked with Dollar Tree Department Stores in Virginia Beach to display posters at balloon filling stations in their stores about the hazards posed by balloons to marine wildlife (Figure 19) (April Strickland, Personal Communication, 2015).

Policies to Reduce Balloon Releases

Some schools, churches, parks and other places where people gather to celebrate events have adopted policies that restrict the release of helium-filled balloons – and also sky lanterns that create litter. For some, this is a logical extension of their existing anti-litter policies. For example, Virginia State Parks have long had anti-litter policies in place, but in 2017-18, they added "no balloon release or sky lantern" language into their brochures and event rental agreements.

Legislative Efforts to Reduce Balloon Releases

Some bans and restrictions have been enacted concerning balloon releases. As of this writing, there are also several active petitions calling for further bans and laws. In most cases, these bans are being implemented on the local level (e.g., town, city, province, etc.) rather than state or country-wide. According to Balloons Blow (2018b), mass balloon releases are illegal in five U.S. states: California, Connecticut, Florida, Tennessee and Virginia. U.S. cities with balloon release laws include: Huntsville, Alabama; San Francisco, California; Louisville, Kentucky; Ocean City, Maryland; Everett, Massachusetts; Nantucket, Massachusetts; Provincetown, Massachusetts; New Jersey – Atlantic City, Bradley Beach, Brigantine, Cape May City, Long Beach Township, Longport, Margate, North Wildwood, Sea Isle City, Somers Point, Upper Township, Ventnor; Wrightsville Beach, North Carolina (Balloons Blow, 2018b and DeVencentis, 2017). In order to prevent releases, some laws also address the types and manner in which balloons are sold. Laws in Nantucket and Provincetown, Massachusetts ban the sale or use of any helium-filled balloon (Balloons Blow 2018b).

Virginia enacted legislation pertaining to balloon releases in 1991. This legislation makes it illegal in Virginia to release 50 or more balloons within a one hour period. The law exempts balloons released by government agencies for scientific or meteorological purposes. While Virginia's law helped to inspire other legislative efforts, several groups are calling for stronger state legislation. In 2015, co-authors

Kathy O'Hara and Christina Trapani worked with the Virginia Aquarium & Marine Science Center and the nonprofit group, Lynnhaven River Now, on a legislative bill to reduce the number of allowable balloons to be released from 49 to zero (Figure 20). When introduced, this bill was met with significant resistance and even some ridicule. While it passed the Virginia State Senate Agriculture, Conservation and Natural Resources Committee, it failed in the Senate. Several senators poked fun at the bill. The bill's sponsor, Senator McWaters, even found 300 balloons placed in his office (Lata, 2015). The Balloon Council stated their opposition to the bill through an email (Appendix A) to the committee members and lobbied against the bill. In a letter to the editor of the The Virginian Pilot/The Beacon newspaper, Lorna O'Hara, Executive Director of The Balloon Council stated: "While some animals may chew latex balloons, researchers have found no credible evidence that balloons have ever caused the death of an animal" (L. O'Hara, 2014).

Figure 20: Mark Swingle, Director of Research and Conservation, Virginia Aquarium & Marine Science Center speaking to a Virginia Senate committee about the harmful impact of balloon litter on marine animals.

The Balloon Industry's Stand on Balloon Releases

The balloon industry is represented by an organization, The Balloon Council, formed in 1990 in response to legislative attempts to ban balloon releases (The Balloon Council, 2018b). The Balloon Council maintains that the impacts of balloon litter on the environment are minimal, that balloon release bans harm small businesses, and that latex balloons are not harmful to wildlife (The Balloon Council, 2018b). When fighting a balloon release ban in New Jersey, a lawyer representing The Balloon Council said, "…the notion that balloon fragments often are responsible for killing water-dwelling creatures is an 'urban myth'" (DeVencentis, 2017). Another spokesperson for the balloon industry said, "No business and no balloon retailer wants to contribute to the harm of any creature, but to say it's a hazard, we think that's way overblown" (Shipkowski, 2017). In a recent article regarding balloon release bans in New Jersey, The Balloon Council stated "...the threat to wildlife has been blown out of proportion. Although latex balloons can be found tangled in trees or litter beaches, they have not risen to the level of common debris like bottles and cans..." and that bans on balloon releases "...are a threat to a lot of mom and pop businesses in the balloon industry" (Fallon, 2017).

The balloon industry claims that latex balloons are not harmful because they are biodegradable. They often cite a 1989 paper (written by a salesman from the balloon industry) that "… a latex balloon will degrade at the same rate as an oak leaf…" (Balloon Council, 2018a; Burchette, 1989).

Instead of legal restrictions on the mass release of balloons, The Balloon Council calls for educating retailers and consumers. The Balloon Council suggest that only latex balloons be used in mass releases, and that should all be "hand-tied, with no tails (ribbon, string, etc.)" (The Balloon Council, 2018b). The Balloon Council created a program called "Responsible Balloon Retailer" to "…educate and promote FUN use of balloons in RESPECT to the environment" (The Balloon Council, 2018c). This program suggests balloon retailers follow several guidelines when selling balloons. The guidelines are demonstrated in Figure 21 below.

Figure 21: The Balloon Council's web site includes this list of commitments to be followed in order to achieve "Responsible Balloon Retailer" status. Note that this commitment does not mention mass releases of balloons. (Source: The Balloon Council).

They also have a Smart Balloon Practices campaign that encourages consumers to never release foil balloons, keep balloons attached to a weight, supervise young children with balloons and dispose of balloons properly (The Balloon Council, 2018d).

Preventing Balloon Releases: A Priority in Virginia

Participants of the 2013 Virginia Marine Debris Summit identified balloon litter to be of particular concern in Virginia along with derelict fishing gear, cigarette butts, plastic bags, and plastic food and beverage containers (Register & McKay, 2014) (Figure 22). One of the near-term actions identified in the Virginia Marine Debris Reduction Plan, published by the Virginia Coastal Zone Management Program, was to design and implement a social marketing campaign targeting behaviors that will reduce balloon litter in the marine environment (Register & McKay, 2014).

Figure 22: Round table discussion identifying priorities in Virginia at the 2013 Virginia Marine Debris Summit.

From 2015 to 2017, the Virginia Coastal Zone Management Program along with Clean Virginia Waterways, OpinionWorks and other partners conducted extensive research to

better understand who plans balloon release events—and, most importantly, why (Witmer, Register & McKay, 2017).

This qualitative and quantitative research was conducted using the principles of Community-Based Social Marketing and led to the development of a social marketing strategy that is reaching and altering the behavior of a specific audience selected as pilot for this targeted approach: brides and grooms who are planning their wedding – especially their "send-off" activity. The resulting campaign—*Joyful Send-off*—is described earlier in this report (Figure 23). This research and development of the *Joyful Send-off* campaign was supported by grants from the NOAA Marine Debris Program and the NOAA Office of Coastal Management to the Virginia Coastal Zone Management Program as well as in-kind support from partners. Reducing balloon litter is part of the Virginia Coastal Zone Management Program's commitment to implementing the Virginia Marine Debris Reduction Plan.

Figure 23: Photographing balloon release alternatives for Joyful Send-off campaign. Photo by Katie Register.

Figure 24: Students from Seatack Elementary, An Achievable Dream Academy, find a foil birthday balloon during a cleanup at Back Bay NWR.

Counting Balloon Litter: the International Coastal Cleanup & Citizen Scientists

While it is impossible to quantify how many balloons enter the marine environment every year, the International Coastal Cleanup (ICC) provides a source of data about where balloon litter can be found. During the ICC, organized annually by the Ocean Conservancy, volunteers not only pick up trash from the world's waterways, they also count and report their findings using a standardized data card. ICC events are held on coastal beaches as well as inland waterways all using the same protocols and data form. Although there are three kinds of balloons that are found during these beach cleanup events (latex, foil and weather balloons), the ICC data form does not distinguish one type of balloon from the others (Figure 24).

In 2014, 904 balloons were recorded by volunteers at Chincoteague National Wildlife Refuge in Accomack County, Virginia – coming in second place to cigarette butts (Clean Virginia Waterways, 2014). During the 2016 ICC in Virginia, 492 balloons were found at Chincoteague National Wildlife Refuge, and another 117 balloon items were found on other beaches in the same county (Clean Virginia Waterways, 2016).

As seen below in Table 1, more than 688,900 balloons were found worldwide during the ICC in the ten year period 2008 through 2017. Of these, 41.9% (N=304,344) were found in the US.
In 2015, CVW further analyzed Virginia's ICC data from 2010-2014, and found that 63.5% (N=3,122 of 4,916) of the balloons reported statewide were found on ocean beaches. These data indicate that balloon litter accumulates more on ocean beaches than on inland cleanup sites. The number of balloons found per volunteer was also significantly higher on the remote ocean beaches (N=3.97 balloons per volunteer) vs. more public ocean beaches (N=.35 balloons per volunteer).

Year	Worldwide	USA	Virginia	Percentage of balloons found during the ICC that were in the USA
2008	77,705	38,181	590	49.1%
2009	82,902	39,744	836	47.9%
2010	75,207	32,153	874	42.7%
2011	93,913	38,535	808	41.0%
2012	69,614	29,582	690	42.5%
2013	52,918	25,282	924	47.8%
2014	62,226	27,070	1,620	43.5%
2015	61,876	24,597	942	39.8%
2016	54,029	25,149	1,472	46.5%
2017	58,551	24,051	819	41.9%
10-Year Totals	**688,941**	**304,344**	**9,575**	**44.3% (10 year avg)**

Table 1: Balloons recorded by volunteers in the International Coastal Cleanup, 2008-2017. Sources: Ocean Conservancy and Clean Virginia Waterways, 2008 - 2017. As published in "Balloon Release Research in Virginia & Reducing Balloon Debris through Community-Based Social Marketing" (2017) by Witmer, Register and McKay.

Other Efforts to Quantify Balloon Litter

With grant funding from the Virginia Coastal Zone Management Program, the Virginia Aquarium & Marine Science Center monitored four remote beaches in Virginia for marine debris starting in April 2014 and ending in June 2018. Volunteers collected data monthly from Chincoteague National Wildlife Refuge (NWR), Fisherman Island NWR, Back Bay NWR, and Grandview Nature Preserve in Hampton,

Virginia. Clean Virginia Waterways is entering all data into NOAA's national database, and analyzing the results. In a 2016 report to the Virginia Coastal Zone Management Program, the authors noted that balloons were the second most common identifiable debris item found on these survey areas, only slightly behind the most common debris item: bottle caps (Table 2) (Register, Trapani & Swingle, 2016).

Rank	Item
1	Bottle/Container Caps
2	Balloons
3	Food Wrappers
4	Lumber/Building Material
5	Plastic Beverage Bottles
6	Plastic Rope/Net
7	Cigarettes
8	Paper and Cardboard
9	Plastic Bags
10	Other Jugs/Containers
11	Plastic Cups
12	Straws
13	Aluminum/Tin Cans

Table 2: Top identifiable marine debris items recorded in 44 months of the Virginia Marine Debris Monitoring Project. Source: Register et al. (2016).

In the 13-year period from 2005 to 2017, balloons were the most common item recorded by researchers from the Blue Ocean Society on board five whale watch boats off New England. Of the 29,173 pieces of trash recorded, balloons accounted for more than 6,306 or 34.4% of all debris (Blue Ocean Society, 2018). Foil balloons have even been reported floating at the ocean surface hundreds of miles offshore (Moore & Phillips, 2011). Balloons have been reported as the most abundant item encountered floating at the mouth of the Chesapeake Bay and offshore waters (K. O'Hara, personal observation).

Since 2012, balloon data has been collected by citizen scientists through the "Virginia Balloon Study," a project conducted by Clean Virginia Waterways and the Virginia Aquarium & Marine Science Center. Citizen scientist data have provided some baseline data of the types, quantities, occasions of release (Mother's Day, Valentine's Day, graduations, etc.) and sources (where possible) of balloon litter throughout the State of Virginia. Since its inception in April 2012, nearly 1,000 reports have been filed on the website, www.VirginiaBalloonStudy.org (Virginia Balloon Study raw data, 2018).

Balloon litter is not just a coastal issue. In Pima County, Arizona, balloon litter was documented during a desert tortoise distribution and density study conducted in 2001 (Averill-Murray, A. & Averill-Murray, R., 2002). By collecting data on balloon litter during 53 days of surveys for tortoises, the authors were able to estimate an absolute abundance of 11,207 balloons on the Ironwood Forest National Monument, which is approximately 200 square miles. In a similar case in the Mojave Desert, Walde et al. (2007) reported on the potential threat to the tortoises by balloon litter. They surveyed for balloon litter after removing 108 cm of ribbon attached to a piece of balloon from the mouth and GI tract of a tortoise. From March to November 2005, 178 new balloons were found in their study area (no size is given for the study area). The recovery plan for desert tortoises of the Mojave lists balloons and other trash items as threats since tortoises are known to eat balloons (U.S. Fish and Wildlife Service, 1994).

Figure 25: Author Kathy O'Hara records foil balloons found during the first survey of Hog Island in 2013.

Virginia's Balloon Monitoring Study

In 2013, researchers Kathy O'Hara and Christina Trapani began monitoring remote beaches throughout Virginia for balloon litter in order to supplement data that were being collected for the Virginia Balloon Study (Figure 25). The first two years of surveys were self-funded by the researchers and depended upon The Nature Conservancy, Virginia Department of Game and Inland Fisheries, and Back Bay National Wildlife Refuge for transportation to study sites. Permits were acquired through the United States Fish and Wildlife Service (USFWS) and TNC to conduct this research.

In 2015, a Virginia Coastal Zone Management Program Grant (FY14 Task 95.03) to Clean Virginia Waterways began supporting this monitoring. Subsequent grants (in FY 15 and FY16) continued to support this monitoring.

In addition to funding and support from NOAA, the Virginia Coastal Zone Management Program, and Clean Virginia Waterways, the success of this monitoring depends on partners including The Nature Conservancy (TNC), Virginia Department of Game and Inland Fisheries (VDGIF), Back Bay National Wildlife Refuge (BBNWR), Virginia Coast Reserve Long-Term Ecological Research Program (VCRLTER), and False Cape State Park (FCSP) that transported researchers to sites that are only accessible by boat or, in the case of FCSP, a 6-mile hike south of BBNWR (Figure 26).

Figure 26: Left: A UTV (utility task vehicle) is used to survey False Cape State Park. Right: Author Katie Register after a survey of Smith Island with Virginia Department of Game and Inland Fisheries (VDGIF) biologist Jeremy Tarwater. VDGIF often helped us with boat rides to the barrier islands.

PROJECT GOALS & METHODS

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The goal of this study is to better understand the abundance, distribution, accumulation and fate of balloon-related litter in the marine environment. Through the Virginia Balloon Study and the International Coastal Cleanup data, we are able to get a snapshot view of this type of marine debris, but by surveying beaches that are remote, difficult to access or inaccessible by the general public, we can get a better idea of the true nature of balloon litter as marine debris in Virginia.

By documenting details on balloon litter, we also hope to identify possible sources beyond mass balloon releases. For example, by looking at balloons and identifying events and occasions, we could determine which are most likely to result in balloon litter. Documenting the condition of each balloon could help us understand how many balloons are being released with ribbons, how many are reaching an altitude that causes them to burst, how many foil balloons are being released despite the warnings not to release them, and more. This information may be very useful when educating the public and policy makers about the problems caused by releasing balloons.

Results of this research will also be used as one measurement of the impacts of Virginia's Community-Based Social Marketing campaign. Monitoring prior to its implementation, and continued monitoring during and after, may help to evaluate the effectiveness of this campaign.

Site Selection

In order to characterize balloon-related litter in Virginia's marine environment, we selected remote beaches with limited access that were not cleaned on a regular basis. Site selection was also based on discussions with Virginia Department of Game and Inland Fisheries and The Nature Conservancy regarding shore bird nesting frequency and island access. The following study sites were selected:

- Cedar Island, Accomack County
- Hog Island, Accomack County
- Smith Island, Northampton County
- Fisherman Island, Northampton County
- False Cape State Park, Virginia Beach

While analyses of all sites will help characterize Virginia's balloon litter overall, these different locations may provide a means to assess any patterns in distribution along the eastern shore and southside of Virginia: north end (Cedar Island), middle (Hog Island) and southern tip (Smith Island) of the eastern shore's oceanside, as well as entrance to the Chesapeake Bay (Fisherman Island) and a remote beach on the southside of Virginia (False Cape State Park) (Figure 23).

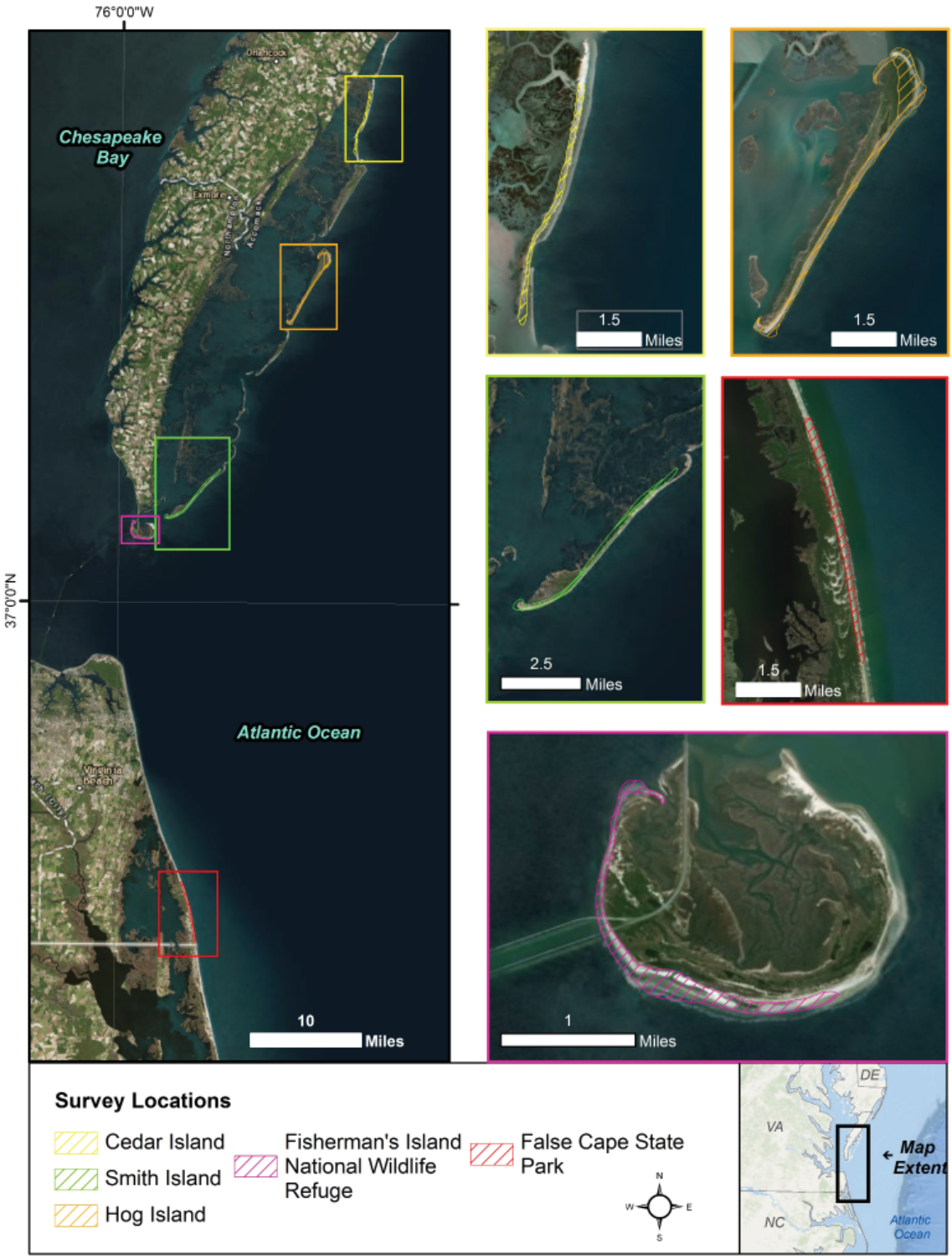


Figure 23: Cedar Island, Accomack County, is approximately 7 miles long and only accessible by boat. Hog Island, Northampton County, is located on the north end of Northampton County. It is approximately 7.5 miles and long and is only accessible by boat. Smith Island, Northampton County, is the southernmost barrier island on the east side of Virginia's eastern shore. Smith Island is approximately 7 miles long and is only accessible by boat. Fisherman Island National Wildlife Refuge, Northampton County, is accessible by vehicle and on foot. It is about 2000 acres and about 2 miles at its widest point. False Cape State Park is accessible by vehicle and on foot. It is located in Virginia Beach, south of Back Bay National Wildlife Refuge extending approximately 6 miles to the VA/NC State line. Map by Gwen Lockhart.

Survey Frequency and Distance

Our study objectives are to monitor each site at least twice a year, and at the same time of year. Survey dates have been dependent on seasonal beach closures due to shore bird nesting. For example, Fisherman Island can only be monitored between September and early-March while monitoring on Smith, Hog and Cedar Islands varies depending on location and quantity of shore bird nests. Only False Cape State Park has no restrictions due to seasonal bird nesting.

Monitoring dates and times are also restricted by the availability of transportation and favorable tidal conditions. For example, the three islands accessible only by boat cannot always be accessed at low tide. Therefore, we often work from mid-tide to mid-tide. Fisherman Island is inaccessible in many areas during high tide so we often survey starting a few hours after high tide. However, weather and boat availability can often shift the timing of surveys and on occasion we conduct surveys opportunistically, even if out of our favored window.

Our goal is to cover at least one mile for each survey. However, survey distance has ranged from 0.25 miles to seven miles depending on boat schedule, tides, weather, and balloon density. Some surveys required two trips in order to cover the desired distance depending on weather, transportation and volume of balloons being found.

Survey Protocols

Surveyors walk the islands looking for balloons and balloon-related litter. For every balloon debris item encountered, the following three variables are recorded:

- Descriptive data (data sheet)
- Location data (GPS)
- Photographic (*in situ* and full image)

On the field data sheet (see Appendix B), descriptive data for each balloon includes the material and quantity of the balloon(s) – latex, foil, or ribbon only; the condition of the balloons (burst, deflated, nub, piece or unknown); the color, shape and, if unusual, size of the balloons; ribbons and other attachments; ribbon color and quantity; and any other characteristics including imprinted messaging such as events and greetings, business/organization names and logos, and handwritten messages. The field datasheet includes a visual guide to balloon types and conditions.

If multiple balloons are found together as if they had been released together, they are recorded as one occurrence and the number of balloons in the bunch are counted. In a few instances, multiple balloons in single bunches are difficult to count in the field due to condition and time constraints. In many cases, conservative estimates as to the number of balloons in the bunch are given. Weather balloons/parts and sky lanterns are also documented during these surveys.

Depending on availability and boat space, volunteers have been recruited to record information on all other marine debris encountered during a survey. Volunteers are not able to participate in surveys at False Cape State Park due to transportation restrictions. We initially used the Ocean Conservancy's ICC data card to record other types of marine debris, but we eventually created our own data card for this project (Appendix C) to include items more specific to our area or items that were often found but not included on the ICC data card. While all balloon-related litter is removed from the survey areas when possible, all other debris is left *in-situ* due to the logistical challenge of carrying and disposing of this amount of marine debris.

GPS coordinates and survey tracks are recorded for each balloon-related litter item using a handheld Garmin E-Trex GPS unit. GPS marks are recorded on the datasheet during the survey, and the GPS is later downloaded to add the actual coordinates to the database. Each record is assigned an individual mark even if several balloons, presumably not related, are found together. These coordinates not only mark the location of each balloon, but allow us to calculate the length of beach covered during each survey. In many cases, our tracks have been recorded and downloaded for later use, if necessary.

Photos of each balloon litter item are taken *in-situ*, before disturbing the debris. In many cases, we pull the debris out of the sand, spread the balloons (and/or ribbons) out, and photograph them again to be sure to capture any significant details (Figure 24). The photos are stored on an external hard drive as well as on DropBox. It is our intention to label each image according to location, date and GPS mark (for example: FCSP20161016_123_01).

With the exception of a very limited number of balloons that were high in the dunes or in other hard to reach areas, every balloon has been removed and put into storage. All collected balloons are bagged/boxed, and each container labeled by survey before being stored.

Figure 24: The in-situ photo on left shows buried foil balloons. The photo on the right reveals the entire bunch of balloons.

Challenges

Weather can affect not just our ability to get to an island for a survey but can also affect the results of a survey itself. Extreme tides (Figure 25) and high winds can wash out or bury much of the debris. Temperatures must also be taken into consideration as extreme heat or cold can slow down researchers or prevent them from covering as much of the survey area as expected. Physical endurance must be taken into consideration as we collect and carry every balloon that is accessible (Figure 26), work in all

weather conditions, walk long distances and encounter biting insects.

Accessibility to islands can also be a challenge as we depend on the generosity of local organizations to donate boat rides to Cedar, Hog and Smith Islands. Since, for the most part, we are “hitching a ride,” we must work around their schedule.

Figure 25: An unusually low tide caught our boat drivers off-guard, changing our plans of surveying half of Smith Island to surveying all of it.

Figure 26: During a 6-mile survey of Smith Island, 333 balloons were removed from the island. Carrying this quantity of balloons can be a challenge during a long survey.

FINDINGS

FINDINGS

From June 2013 to November 2017, we conducted 46 balloon-related litter surveys: Hog Island (N=10), Fisherman Island (N=13), Cedar Island (N=6), Smith island (N=8) and False Cape State Park (N=9). Survey distances ranged from 0.25 mile to 7.3 miles. Our surveys totaled approximately 111 linear miles of remote Virginia beaches. During this period, 11,441 balloons and balloon-related litter items were recorded. GPS coordinates are collected during all surveys to give us an idea of balloon-related litter density at each site. Unfortunately, coordinates collected for three 2013 surveys are unavailable (Fisherman Island [9/3/13] and Smith Island [7/25/13 & 8/9/13]). Therefore, **the following findings about density and seasonality include 43 of the 46 surveys.** The total number of balloon-related litter from these 43 surveys totaled 10,897 pieces.

In this section, after each data presentation we provide a brief discussion of our findings and possible implications. Data are organized into the following categories.

Density of Balloon Litter Among Study Sites
Abundance
Composition of Balloon Litter
Types and Amounts of Balloons
Condition of Latex and Foil Balloons
Plastic Ribbons and Other Balloon Attachments
Balloon Shapes and Characters
Event and Greeting Messages
Business, Organization and Other Names and Logos
Personal Notes and Messages
Weather Balloons
Shoreline Location of Balloon Litter
Seasonality of Balloon Ltter
Seasonality of Event and Greeting Balloons
Comparison of Balloon vs. Other Types of Debris
Other Unusual Finds Along the Way
Observations of Wildlife Interactions with Balloon Litter

Density of Balloon Litter Among Study Sites

Balloon litter density varied between sites (Table 3). Cedar Island, the northernmost site and the site furthest away from any populous area had the lowest balloon litter density at 39.1 pieces per mile while Fisherman Island, the site situated at the mouth of the Chesapeake Bay had the highest balloon litter density at 202.3 pieces per mile.

Location	# of Surveys	Total Miles Surveyed	Total Pieces of Balloon-Related Litter	Average Number of Pieces of Balloon-Related Litter per Mile
Cedar Island	6	21.0	822	39.1
Hog Island	10	37.9	3,197	84.4
Smith Island	6	15.8	1,687	106.8
Fisherman Island	12	14.2	2,872	202.3
False Cape State Park	9	22.1	2,319	104.9
Totals	**43**	**111.0**	**10,897**	**107.5**

Table 3: Average number of pieces of balloon-related litter recorded per linear mile of coastline surveyed.

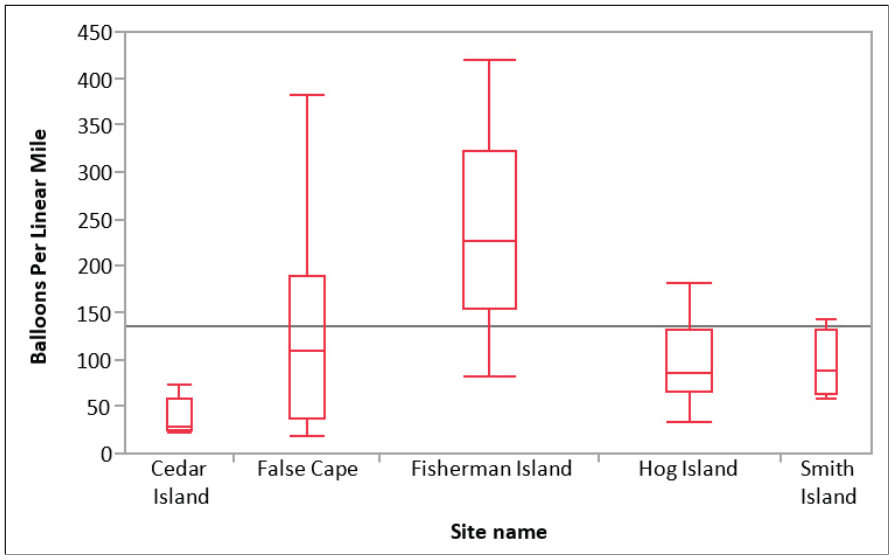


Figure 27: Analysis of balloon litter per linear mile for the five sites indicate that balloon-related litter was more abundant on Fisherman Island NWR and False Cape State Park.

Using a Tukey-Kramer HSD, analysis of the data indicates that the mean number of balloons per linear mile for Fisherman Island and for False Cape are significantly different (larger in this case) than the other locations, which do not have a significant difference (Figure 27).

Abundance

Since survey frequency varied per site, comparison of relative abundances was used to determine variations in the types and quantities of balloons found between sites. Relative abundance of latex, foil and weather balloons shows more latex balloons as compared to foil were collected at Fisherman Island and False Cape (Figure 28). To a lesser extent, foil balloons were more abundant than latex balloons on Hog and Smith Islands. Weather balloons were primarily recorded on Hog and Cedar islands.

Comparison of the number balloons versus plastic ribbons per site shows plastic ribbons were more abundant at Fisherman Island and False Cape as compared to our other sites (Figure 29).

Discussion:

We can speculate about the reasons behind the differences in density of balloon and ribbon litter among the sites. Differences may be due to island location, proximity to population centers, storms,

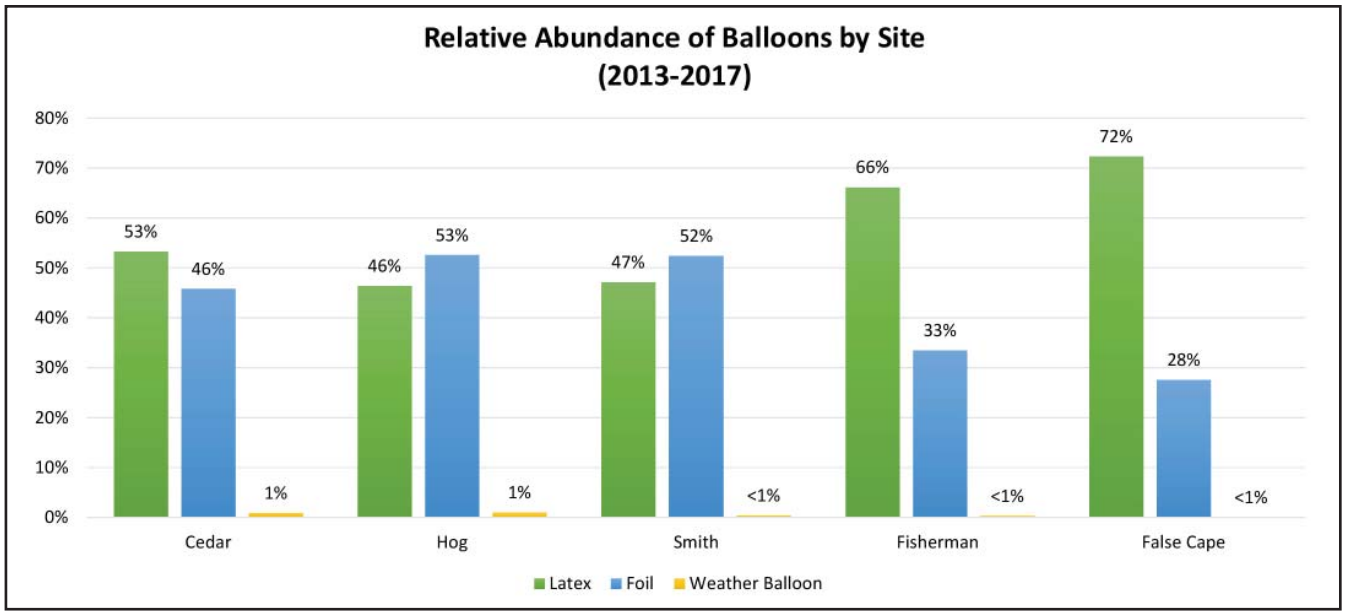


Figure 28: Comparison of balloon types by study site.

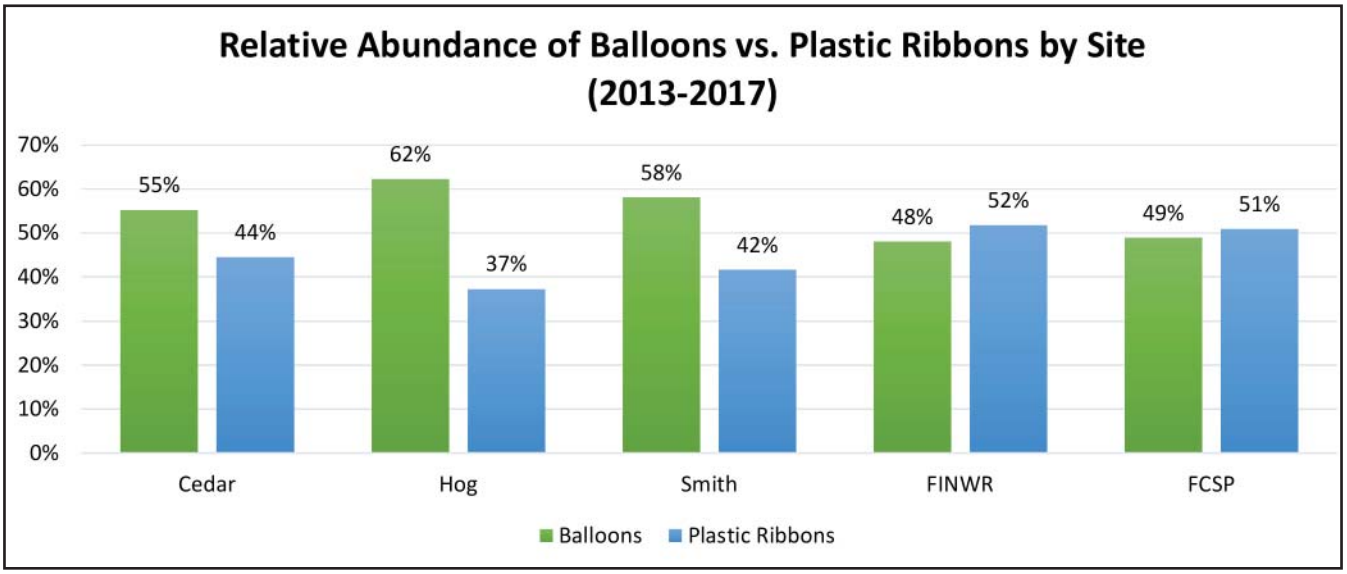


Figure 29: Comparison of balloons vs. plastic ribbons. Balloon litter items outnumbered plastic ribbons at three monitoring sites: Cedar, Hog and Smith Islands. The number of balloon and ribbon litter items on Fisherman Island NWR and on the beach of False Cape State Park were nearly the same.

or ocean and atmospheric currents. For example, as mentioned earlier, Cedar Island is furthest away from any populous areas than the other monitoring sites. It is also slightly west of its neighboring islands so floating litter may accumulate on those islands more frequently than on Cedar Island. From ICC data, we know that balloon litter accumulates on the beaches of the Chincoteague NWR that is on Assateague Island. This island is positioned much further east and may be catching litter coming from the ocean. Fisherman Island is completely surrounded by water from the Chesapeake Bay, Smith Island Inlet and the Atlantic Ocean. Assessing the roles played by storms and oceanic and atmospheric currents in the distribution of balloon litter is beyond the scope of this research.

Findings of more latex balloons at Fisherman Island and False Cape State Park as compared to other sites could also be due to their closer proximity to dense population areas. False Cape State Park is the closest site to highly-populated Virginia Beach but is also the most accessible to the public. One compounding variable that might be influencing the number of litter items we found: several beach cleanups are held each year at False Cape, and we've talked to many beach walkers who have picked up balloons as they walk on that beach, especially in the warmer months.

The number of plastic ribbons at False Cape is attributed in part to a fence at the southern border of our study site. The fence lies perpendicular to the beach and is intended to minimize vehicle traffic from North Carolina. It also tends to trap balloon litter. Consequently, for each survey we spent a considerable amount of time recording information and removing balloon debris from the fence. This debris was mostly ribbons.

While the information above would explain the large number of plastic ribbons recorded at False Cape, it does not explain the number of ribbons on Fisherman Island. However, the same principles may be at play. Fisherman Island is undergoing considerable erosion on the southwestern portion of the island which lies within our study site. Due to this erosion, numerous trees and bushes are exposed at the highest portion of the beach which tend to trap balloon litter in their branches. There are also several metal structures on the beach in our survey area that trap this litter (artifacts from when the island was used as a military installation during World War I and II). As a result, we spend a good amount of time during our surveys at Fisherman Island removing balloon litter from branches and structures and most of this litter is plastic ribbons.

Composition of Balloon Litter

Detailed information has been recorded on 11,441 balloon litter items from 46 surveys. This includes 6,145 latex, foil, and weather balloons (54%), 5,059 plastic ribbons (44%), and 237 other balloon attachments (2%) (Table 4). One sky lantern was also recorded at False Cape State Park in October 2015.

Types and Amounts of Balloons

For each balloon recorded, specific information was obtained on type (latex, foil, or weather balloon) and quantity. Latex balloons have been our most common finding, accounting for 56% (N=3,460) of all balloons (Figure 30). Foil balloons comprised 43% (N=2,649) and weather balloons accounted for the remaining 1% (N=36).

Item	Number found
Latex Balloons	3,460
Foil Balloons	2,649
Plastic Ribbons Only (not attached)	1,438
Plastic Ribbons (attached to balloons)	3,621
Other attachments (disks, notes, etc.)	237
Weather Balloons	36
Total	**11,441**

Table 4: A breakdown of types and amounts of balloon-related litter recorded.

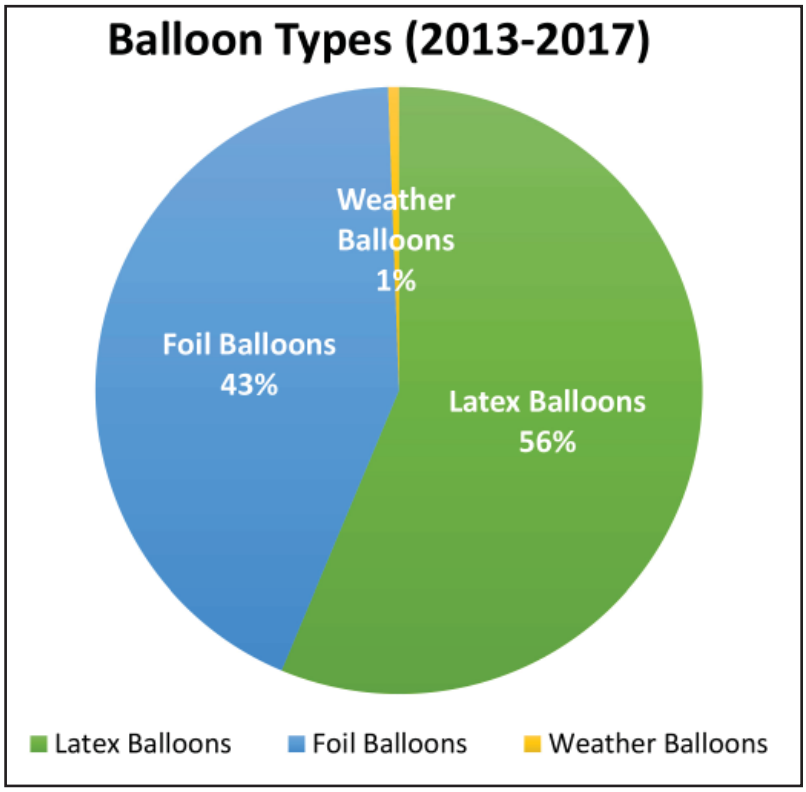


Figure 30: Comparison of types of balloons recorded indicates that latex balloons are the most common type of balloon in the study areas.

Discussion: The amount of balloon litter on Virginia's remote beaches is of concern especially since these areas are designated for protecting wildlife such as nesting sea turtles, diamondback terrapins, coastal and migratory birds, and other species. Speculation as to why we find more latex balloons as compared to foil could be that they are less expensive and bought in larger quantities. Latex balloons are also more likely to be used in outdoor events and occasions, again due to their lower cost. Finally, the balloon industry advises against the use of foil balloons for releases. Therefore, latex balloons would be preferred for mass balloons releases (Balloon Council, 2018b).

The balloon industry claims that latex balloons are biodegradable and therefore, not harmful (The Balloon Council, 2018a). While we are unable to determine how long most of these latex balloons had been in the environment, in one case we have some idea. In July 2014, three foil balloons were found on Hog Island, tied together and imprinted with "Happy Holidays." Attached to these balloons were 18 green and red latex balloons in various conditions. If we could assume that these balloons were purchased in December, both the latex and foil balloons had lasted for at least seven months. While it could be argued that there is no definitive way to determine when these balloons were released, we believe this case is noteworthy. One could assume the longer latex balloons persist in the marine environment, the greater the potential harm they pose to marine wildlife.

Condition of Latex and Foil Balloons

Descriptive data were recorded for every latex and foil balloon as to whether it was burst, deflated, a nub, a piece, or unknown. In total, condition codes were recorded for 91% of all balloons. Of these, 65% of all balloons were either deflated (36%) or burst (29%) (Figure 31). The remaining balloons were nubs (20%), pieces of balloon (6%) or unknown (9%).

Analyses of all latex balloons shows a large percentage were in a burst condition (46%) (Figure 32). The remaining latex balloons were mostly nubs (28%) followed by deflated (14%). Only a few pieces of latex balloons were recorded (4%) while the condition of remaining balloons was not identified at the time.

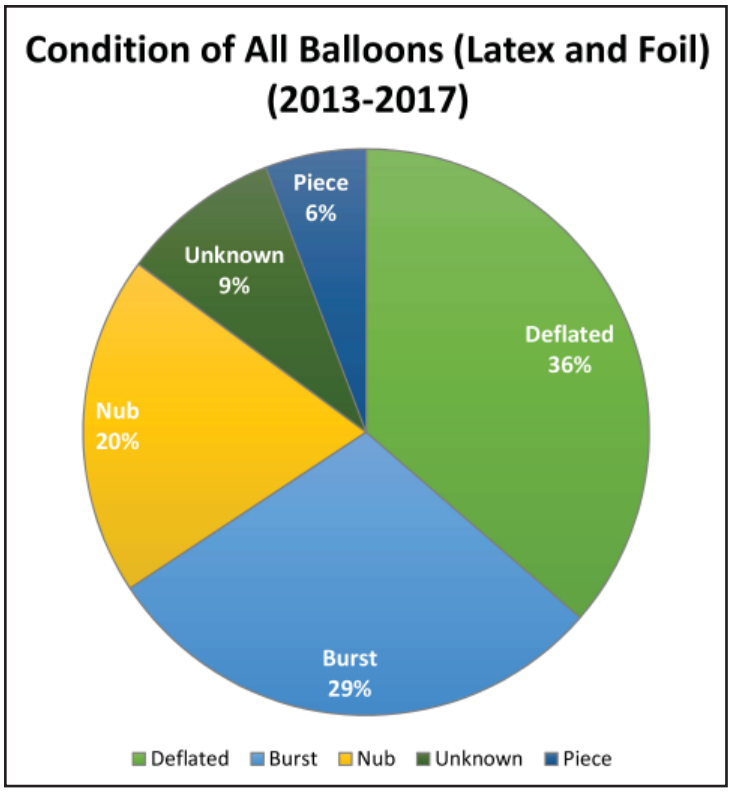


Figure 31: Of all balloons recorded, the majority were deflated (36%) or burst (29%).

Analyses of all foil balloons shows 65% were in a deflated condition (Figure 33). Fewer foil balloons were found to be burst (9%), nubs (8%) or pieces (8%). Condition of the remaining foil balloons were either unknown or unspecified.

Overall, the most prevalent findings among all balloons in terms of condition were deflated foil balloons (28%) and burst latex balloons (26%) (Figure 34).

It is important to note that many foil balloons encountered in this study have lost the metallic paint. These balloons often resemble clear plastic bags and are identified as foil balloons from their characteristic heat-sealed edges. We often commented how similar these balloons resemble moon jellyfish (*Aurelia aurita*), especially in deflated and burst condition. In the following sections, comparisons are

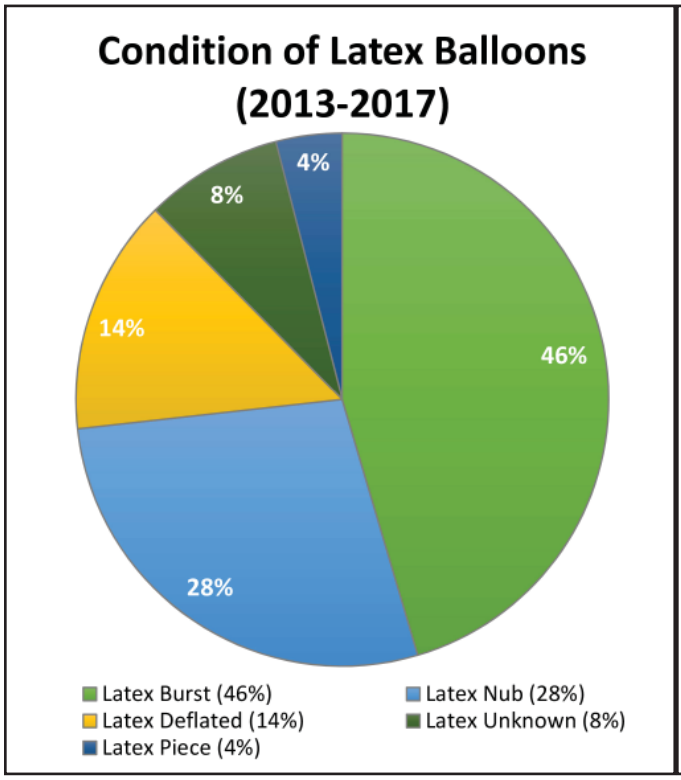


Figure 32: 46% of all latex balloons recorded were in the burst condition.

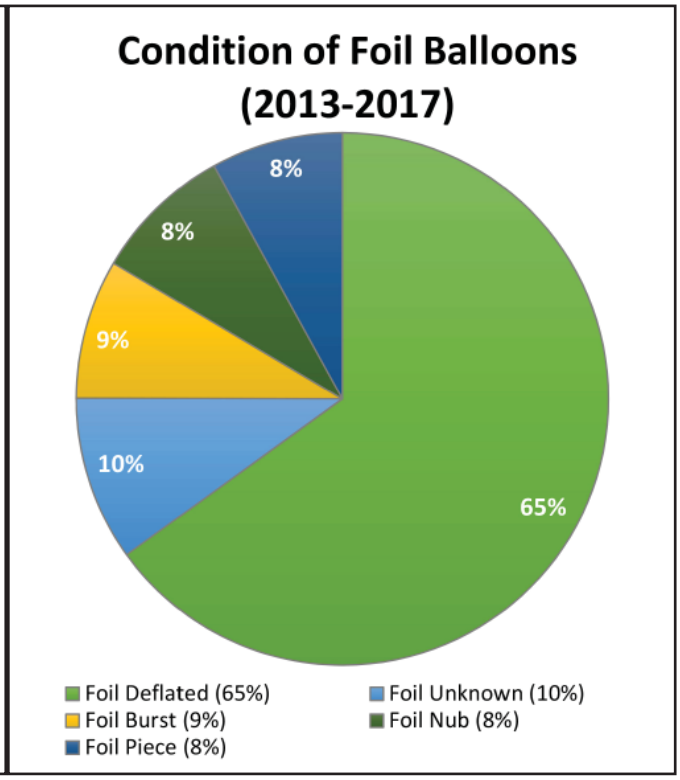


Figure 33: 65% of all foil balloons recorded were deflated.

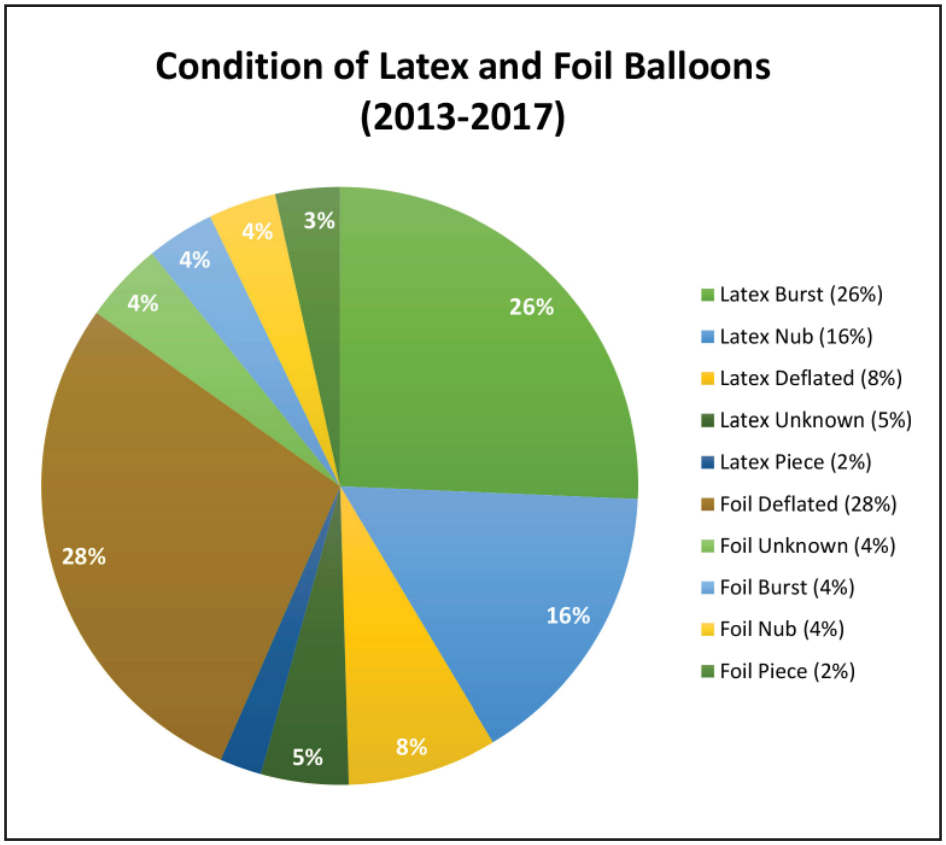


Figure 34: The majority of balloons recorded were deflated foil (28%) and burst latex (26%).

made for foil balloons found imprinted with specific event and greeting messages, as well as cartoon characters and images. For these two analyses, counts would have likely been higher if faded balloons had not lost their metallic paint, imprinted messages and character images.

Discussion: The most common type of balloons found on Virginia's remote beaches were latex, of which 46% were burst. The fact that many latex balloons found in our study appeared to have reached an altitude causing them to burst is an interesting finding in itself. It also raises additional questions as to the trajectory of latex balloons. What percentage of latex balloons go straight up and fall back to earth relatively close to their point of release vs. balloons that travel distances depending on weather and winds?

As mentioned earlier, ingestion of marine debris by wildlife has long been attributed to the resemblance of debris to natural prey, so the presence of burst latex balloons on Virginia's remote beaches is a cause for concern.

Plastic Ribbons and Other Balloon Attachments

At least 5,059 plastic ribbons were recorded during this study period, accounting for 44% of all balloon-related litter. 66% of all balloons had plastic ribbons attached (Figure 35). On occasion, multiple plastic ribbons entangled in a bunch could not be accurately counted in the field. In these cases, ribbon bunches were recorded as one unless distinct colors were noted. For example, a bunch of white plastic ribbons would be counted as a single plastic ribbon but if three distinct colors were noted, the bunch would be counted as three ribbons. Therefore, while our plastic ribbon count is large, it is also conservative.

Most plastic ribbons found during this study were attached to balloons (72%) (Figure 36). The remaining 28% had become detached from balloons and were categorized as plastic "ribbon-only."

Comparisons of balloon types with plastic ribbons, show most latex balloons had plastic ribbons attached (86%) (Figure 37). In contrast, the majority of foil balloons were found without attached plastic ribbons (59%) (Figure 38).

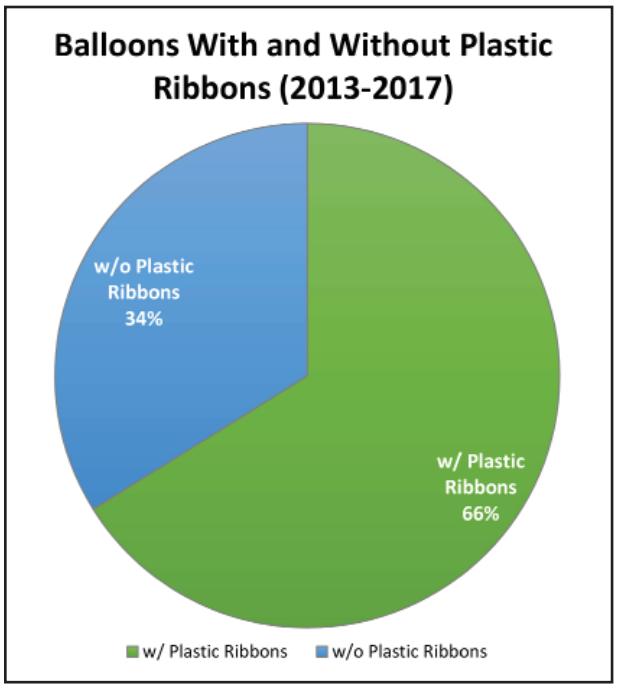


Figure 35: The majority of balloons recorded had plastic ribbons attached.

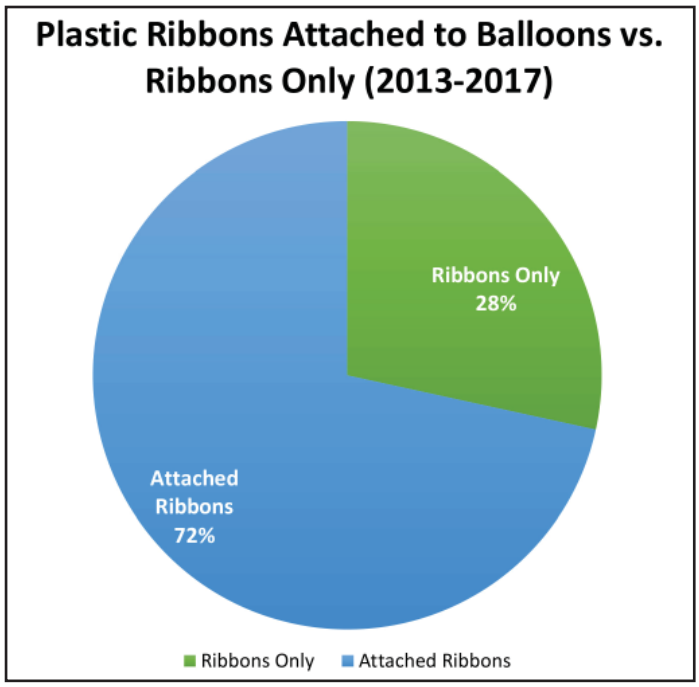
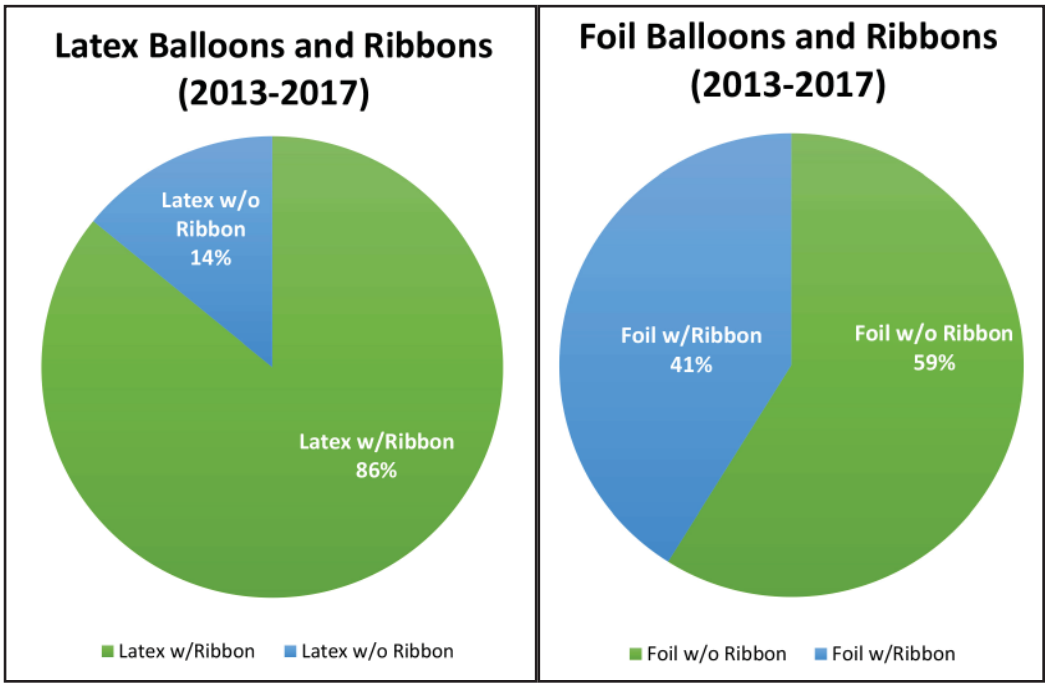


Figure 36: The majority of ribbons recorded were attached to a balloon (72%).

In addition to plastic ribbons, 237 other balloon-related litter items were recorded (Table 5). These included plastic discs (N=71) and clips (N=56) used to seal balloons or attach plastic ribbons, as well as personalized items such as handwritten notes, a bottle of bubbles



Figures 37 & 38: Comparison of latex & foil balloons with and without ribbons.

Type of attachment	Number
Plastic discs	71
Plastic clips	56
Plastic tape	44
Plastic valve	18
String	9
Black plastic strip	5
Other plastic attachment	5
Fishing line	4
Boa	2
Foil decoration	2
Music box	2
Bow	1
Bubble bottle (purple)	1
Card	1
Cup	1
Golf tee	1
Hair tie	1
Masking tape	1
Netting	1
Note	1
Plastic banana clip	1
Plastic glow ring	1
Plastic heart	1
Plastic star	1
Plastic pom pom	1
Tack	1
Twist tie	1
WANA WV tag 5118	1
Yarn	1
Zip Tie	1
Total	**237**

Table 5: List of types and quantities of other attachments on balloons.

Figure 39: Clockwise from top left, a latex balloon with a plastic disc attachment, latex balloons with plastic valve, foil balloons with a boa.

and two boas (Figure 39). We often found pieces of plastic tape attached to plastic ribbons. While the tape indicates that a foil balloon was once attached to a ribbon, we counted the tape as an attachment.

Discussion: The prevalence of plastic ribbons on remote beaches in Virginia is one of the more unexpected findings of this research to date. The predominance of these ribbons attached to latex balloons vs. foil could be attributed to the fact that most plastic ribbons are tied onto latex balloons, whereas plastic ribbons are usually attached to foil balloons with tape. In the marine environment, once wet, this tape and the attached plastic ribbon are more likely to fall off foil balloons. This may also account for our numerous plastic “ribbon-only” findings.

Shape	Number
Star	505
Heart	159
Square	59
Butterfly	25
Cupcake	17
Flower/Scalloped	12
Number/Letter "0"	7
Dolphin	5
Numbers (1, 2, 3, 7)	5
Letter "C"	4
Car	3
Football	3
Other Letters (F, S, other)	3
Bear	2
Candle	2
Fish	2
Owl	2
Ribbon	2
Snowman	2
Ball	1
Barbeque Grill	1
Baseball	1
Basketball	1
Bowtie	1
Camera	1
Champagne Bottle	1
Cross	1
Devil	1
Dog Bone	1
Egg	1
Elmo	1
Glass	1
Hammer	1
Minion	1
Mom	1
Pumpkin	1
Rocket ship	1
Shamrock	1
Spiderman	1
Sun	1
Trophy	1
Truck	1
Other Shapes	20
Total	**862**

Table 6: Shapes of 862 foil balloons recorded.

Balloon Shapes and Characters

Of the 2,649 foil balloons recorded, 862 were noted for their unique shape. Shaped balloons accounted for 32% of all foil balloons recorded. These balloon shapes were organized into 43 categories. Star-shaped balloons comprised the majority of unique shapes with (N=505). Other abundant shapes were hearts (N=159), squares (N=59) and butterflies (N=25) (Table 6, Figure 40). Five

Figure 40: 862 shaped balloons have been recorded. The star shaped foil balloon (top left) is the most common shaped balloon with 505 recorded.

dolphin-shaped foil balloons have been found to date, three on the same day in July 2014 at different coordinates on Hog Island. Some of the larger and more unusual shaped balloons include a devil, cross, barbeque grill, Spiderman and a balloon shaped like the word “MOM.”

We also found foil balloons imprinted and/or shaped with images of popular cartoon characters. To date, 174 of these balloons have been recorded with thirty-six different character images (Table 7). Foil character balloons accounted for 6% of all foil balloons recorded. “Smiley face” balloons are in the lead (N=32) (Figure 41) with Spiderman balloons as a close second (N=25).

Characters	Number
Smiley	32
Spiderman	25
Mickey	23
Minnie	10
Elmo	8
SpongeBob	7
Emojis	6
Frozen Princess	5
Garfield	5
Minion	5
Cars	3
Ninja Turtles	3
Paw Patrol	3
Peppa Pig	3
Princesses	3
Sesame Street	3
Tinkerbell	3
Batman	2
Curious George	2
Frozen	2
Frozen Snowman	2
Hello Kitty	2
Thomas Train	2
Toy Story	2
Trolls	2
Avengers	1
Bubble Guppies	1
Disney Fairies	1
Disney Monster	1
Disney Other	1
Justice League	1
Little Mermaid	1
Ponies	1
Star Wars	1
Superman	1
Transformers	1
Total	**174**

Table 7: A list of characters recorded during all surveys.

The rights of character images printed on balloons are held by companies. For instance, the images of Mickey and Minnie Mouse are owned by The Disney Company, while SpongeBob and Teenage Mutant Ninja Turtles are owned by Nickelodeon. We attempted to identify the parent company of each image and grouped them accordingly (Table 8). As a result, The Disney Company accounted

Figure 41: Clockwise from top left: The “smiley face” balloon is the most common character balloon recorded; Mickey Mouse; Teenage Mutant Ninja Turtles; Spiderman.

Parent Company	Number
The Disney Company /Marvel Entertainment, LLC (Spiderman, Avengers)/Lucasfilm Ltd. LLC (Star Wars)	78
The Smiley Company	32
Nickelodeon (SpongeBob, PAW Patrol, Peppa Pig, Teenage Mutant Ninja Turtles, Bubble Guppies)	17
Sesame Workshop	11
Universal Studios (Minions)/DreamWorks (Trolls)	7
Emoji	6
Paws, Inc (Garfield)	5
American Comics (Batman, Superman)	3
Entertainment One (Peppa Pig)	3
Other (Princesses)	3
Houghton-Mifflin Publishers (Curious George)	2
Sanrio (Hello Kitty)	2
Hasbro (My Little Ponies, Transformers)	2
HIT Entertainment (Thomas the Train)	2
DC Comics (Justice League)	1
Total	**174**

Table 8: We attempted to identify the parent companies of the many character balloons recorded. The Disney Company accounts for almost half.

for 78 of the 174 (45%) character balloons. Balloon images owned by the The Smiley Company and Nickelodeon were also among our top finds in this category.

Discussion: Foil balloons with specific shapes and character images accounted for 38% of all foil balloons recorded. Not only are these specific types of balloons more expensive than latex, but their unique shapes and characters may suggest that most were purchased for personalized events as opposed to mass balloon releases.

Event and Greeting Messages

Both foil and latex balloons can be purchased with pre-printed messages indicating specific events and greetings such as “Happy Birthday,” “Congratulations,” and “Get Well Soon” (Figure 42). We refer to this category of balloons as “event and greeting balloons.” Event and greeting balloons were sometimes found tied in bunches to additional foil and latex balloons. For example, in one record we found three foil balloons imprinted with “Happy Holidays” attached to 18 green and red latex balloons. Event and greeting balloons have been noted 684 times totalling 852 balloons (Table 9). In total, 14% of all balloons recorded were associated with specific events and greetings.

Records of event and greeting balloons were grouped into 34 categories for analyses. More than half of these occurrences (52%) were in the category for “Birthday” (Figure 43). “Graduation” (11%) and “Mother’s Day” (7%) balloons have also been among our top finds.

Discussion: Most balloons associated with events and greetings recorded in this study indicated personalized events (e.g., birthday, Mother’s Day, Valentine’s Day, etc.).

While it is impossible to determine when most balloons found in our study were released, some event and greeting balloons can suggest this information and possibly indicate their duration in the environment. For example, if we could assume that the “Happy Holidays” balloons mentioned above were purchased in the month of December, we then propose that these foil and latex

Occasion	Number of Records with Event/Occasion Imprinted Balloons	Number of Balloons
Happy Birthday	364	436
Graduation	77	103
Mother's Day	49	58
Baby	29	35
Congratulations	26	35
Valentine's Day	25	26
Get Well	20	32
Love	18	20
Your Day	18	20
You're Special	10	11
Father's Day	9	10
Memorial	9	10
Anniversary	3	3
Welcome Back	2	3
Celebration	2	2
Christmas	2	2
Party Here	2	2
Thinking of You	2	2
Best Wishes	2	1
Happy Holidays	1	21
Happy Retirement	1	6
Thank You	1	2
Champion	1	1
Farewell	1	1
Grand Opening	1	1
Happy Nurse's Day	1	1
Just Because	1	1
Opening Night	1	1
Proud of You	1	1
Sale	1	1
Smile, Jesus Loves You	1	1
St Patty's Day	1	1
You're the Best	1	1
You're #1	1	1
Total	**684**	**852**

Table 9: A list of all balloons with special event messages

Figure 42: Examples of special event balloons (top to bottom): Birthday, Valentine's Day, Graduation, Mother's Day.

balloons were at least seven months old when they were found in July 2014 on Hog Island. We found both Valentine's Day and Mother's Day balloons six months after these events and a Father's Day balloon after nine months. It will be important to continue to note this type of information in future studies. Balloon litter is a unique form of marine debris as it is often

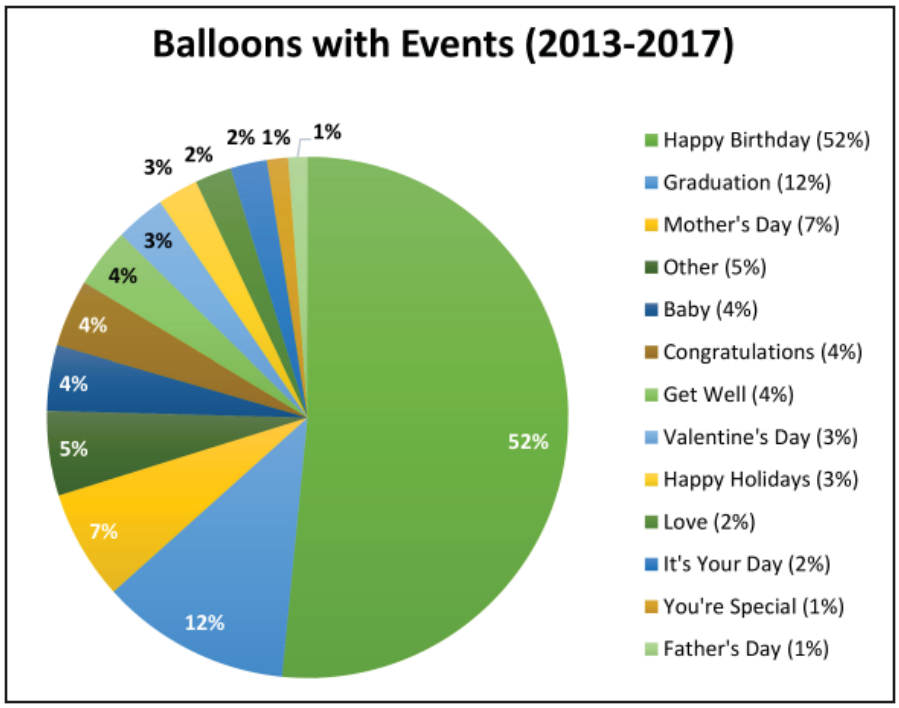


Figure 43: Birthday balloons made up more than half of all balloons representing events.

pre-planned and intentional. Several foil balloons found with handwritten memorial messages demonstrates this intent. Balloons with generic greetings and messages (Happy Birthday, Happy Valentine's Day, etc.) represented 32% of all foil balloons recorded.

Business, Organization and Other Names and Logos

While it is nearly impossible to identify the source of most balloons found in the environment, on occasion we come across balloons that practically have a return address via printed names and/or logos. And while the exact sequence of events that lead to their release is unknown, these types of balloons are always among our most interesting finds that provide clues about their source and perhaps even their distance traveled.

Figure 44: This balloon found on Hog Island originated from a restaurant in La Grange, Kentucky.

We encountered balloons on 75 occasions imprinted with names and/or logos of 56 businesses, organizations, and other groups (Appendix D). This included a deflated yellow latex balloon from a restaurant in Kentucky (Figure 44), a burst red latex balloon from a foam-spray company in Pennsylvania, and 15 green balloons tied together from a tree service business in New York. In total, 123 balloons can be attributed to this category of balloons with names and logos.

For some businesses, balloons with their name and/or logo were found on multiple occasions. For example, we have four records of balloons in different locations from "Chick-fil-A" and four others from "Chuck E. Cheese." Three incidents involved latex balloons from the real estate company Weichert Realtors; three were latex balloons found tied together on Hog Island in June 2016 (Figure 45), and the others were balloons found in two separate locations on Smith Island in October 2016.

Figure 45: Latex balloons from Weichert Realtors found on Hog Island. This company has offices all over the country.

Somewhat surprising was the finding of two balloons from the same dental practice in Virginia. The first balloon was recorded in September 2017 on Fisherman Island, and the other was found the next month at False Cape State Park. Balloons promoting special events are also found including two blue latex balloons for "Walk to Cure Arthritis."

Comparison of the abundance of latex versus foil balloons in this category shows most of these findings have been latex (80%) (Figure 46).

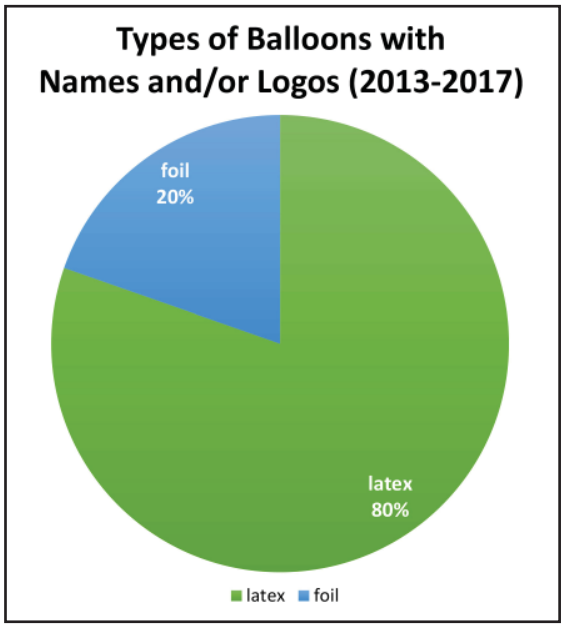


Figure 46: The majority of balloons with names and/or logos are latex.

To determine any trends in types of businesses and organizations using balloons, we organized our counts into 11 categories: Food & Beverage; Real Estate; Shopping & Retail; Grocery Store; Car Dealership; Healthcare; Broadcast & Communication; Home & Business Services; School/Fire Stations; Bank/Tax Services; Construction Companies; Non Profit Organizations; and Other. The largest number of balloons can be traced to Food & Beverage businesses (20%) and Real Estate companies (17%) (Figure 47).

Discussion: Most of the balloons found with names and logos were latex balloons. Since latex balloons are less expensive than foil, it would be more cost effective to use latex balloons for advertising purposes especially if balloons are intended as public giveaways. More costly foil balloons are perhaps more likely to be used for displays and events. While balloons from Food & Beverage businesses were most common, we were somewhat surprised to find balloons from eight real estate companies.

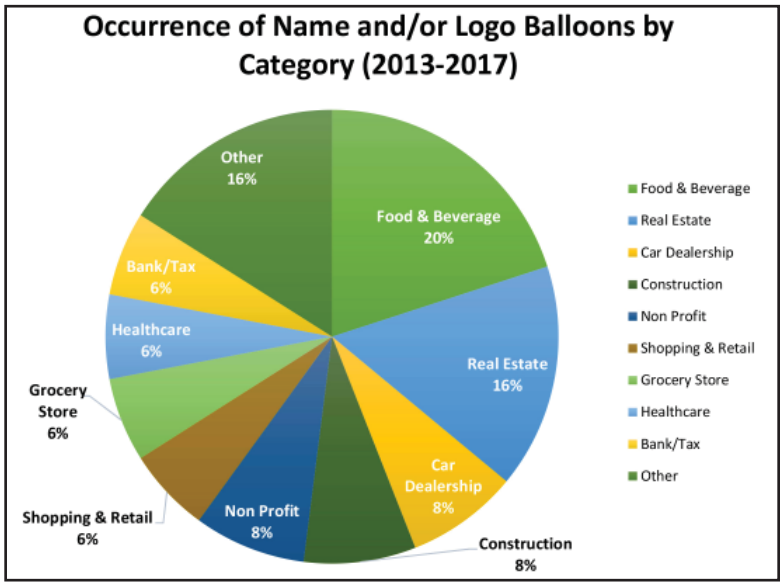


Figure 47: The majority of balloons found with names or logos originated from food & beverage businesses or real estate companies.

If the release of balloons found in this study could be linked to their business location, this could provide insight to the distance traveled by balloons.

Personal Notes and Messages

Personal notes and messages written and/or attached to balloons were found on 18 occasions. Most messages were handwritten directly on the balloons. One balloon had a note attached with a string in a sealed plastic bag. Another, inscribed with a hand drawn face and the name "Jim," had a paper cup attached with yarn as if a drink was being sent along with the balloon.

Figure 48: A message to heaven written on a foil balloon and presumably released on purpose.

The intent of most messages appear to be in remembrance of a deceased loved one (Figure 48). Other messages included a birthday greeting for three children with names written on three different balloons, and a "Xmas 2015" message that included the names of 12 people (Figure 49). All but three of these events used foil balloons. A complete list of all balloons and messages is provided in Appendix E.

Discussion: The majority of balloons found with personal notes and messages appear to have been released in remembrance of loved ones. In these instances, releases are carried out perhaps by those who believe their messages will somehow reach their loved ones, or these releases may simply be a symbolic gesture of "letting go." In any case, while some balloons released into the environment may be accidental, we can assume that the release of these balloons was intentional. The use of mostly foil balloons for this purpose could be because foil balloons are simply easier for writing. Many of these balloons were hearts and stars which may add to their appeal. Helium-filled foil balloons may also be more convenient than latex to transport to a desired location for release without bursting.

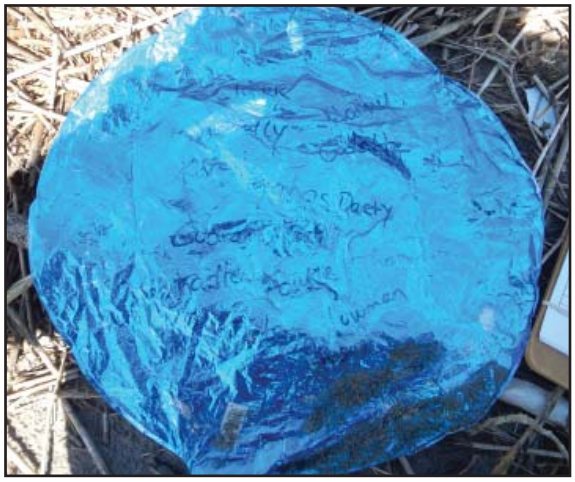


Figure 49: "Xmas Party 2015" written on a foil balloon found in March 2016.

As previously discussed, on rare occasions during this study, we have found balloons that could provide clues on their time of release and/or duration in the environment. For instance, the foil balloon inscribed "Xmas Party 2015" was found on Smith Island in March 2016. While we do

not know when this balloon was released, it was most likely three months old when we found it. In another instance, the message "RIP Deandra I Love You 3-5-15" was written on a pink heart-shaped foil balloon. This balloon was found on March 17, 2016 and may have been released the same month when it was found, marking a year after the date inscribed on the balloon.

Weather Balloons

Thirty-six weather balloons were noted during this study period. In some cases these counts included entire weather balloons, while others consisted of weather balloon components such as foamed-plastic instrument boxes, radiosonde, parachutes of plastic sheeting, strings, wires, and latex or synthetic rubber balloons (Figure 50)—all of which can pose threats to wildlife in terms of ingestion and entanglement. Appendix F lists the locations, dates and findings for all weather balloons recorded to date as well as additional images of weather balloon findings. Most weather balloons were found on Hog Island (N=20), followed by Fisherman Island (N=5), and Smith Island (N=5). (Figure 51).

Figure 50: This weather balloon found on Cedar Island consisted of two instrument boxes, cotton string, latex balloon and plastic parachute.

Discussion: We intend to conduct further investigations of the weather balloons we find which may provide information on their origins. For instance, several are marked with the name of manufacturers (e.g., Lockheed Martin), and some have serial numbers which could lead to information on their release location.

We acknowledge the following calculations are based on many assumptions, but for the sake of argument, if a NOAA weather station releases 730 weather balloons per year (2 per day every day), and if the 36 records of weather balloons found at our barrier island sites originated from just one of these stations, this would represent less than 5% of all weather balloons released. One would then wonder where the remaining 95% of these balloons landed and how many were in the marine

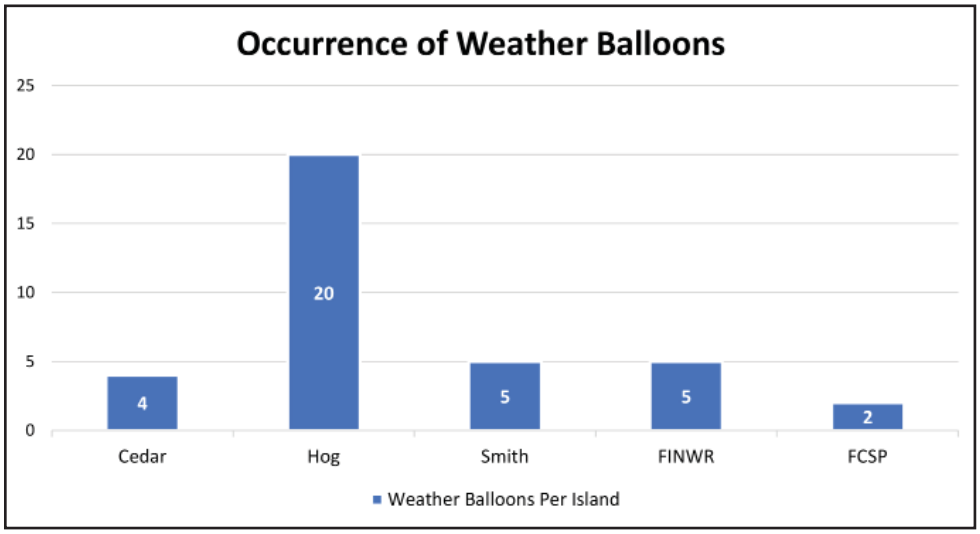


Figure 51: Occurrence of weather balloons by balloon survey site, 2013-2017.

environment. According to the National Weather Service, of the 75,500 weather balloons released each year in U.S. states and territories, 20% are found and returned using mailing bags and instructions attached to weather balloons. If this data could be accessed from the National Weather Service, it would provide important information on time and distance traveled by weather balloons.

Shoreline Location of Balloon Litter

The location of all balloon debris was recorded according to the following beach profiles: "low" (swash zone from water to beach face), "mid" (beach face to high tide line) and "high" (high tide line to dune vegetation). The majority (60%) of balloon litter was found above the high tide line and in the dunes (Figure 52). Most of the remaining items were found in the mid-beach (36%), with far fewer found at or near the water's edge (4%). This pattern holds true at each study site (Figure 53).

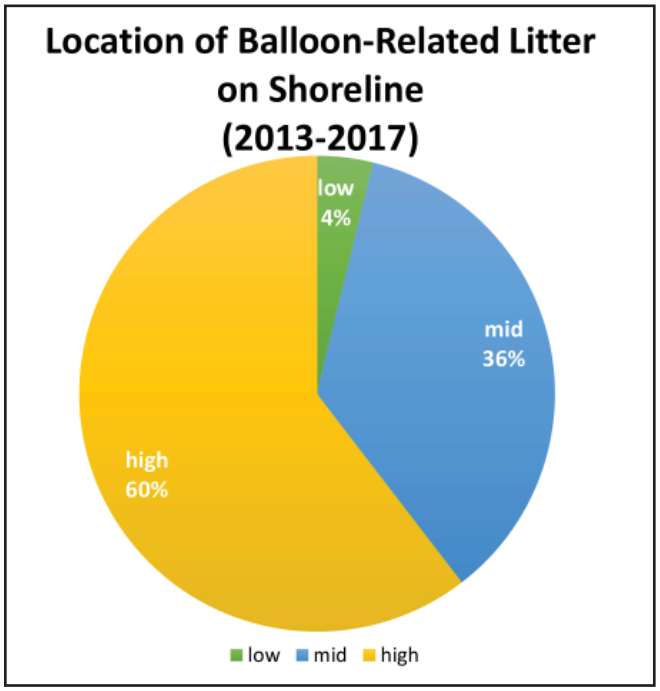


Figure 52: The majority of balloon-related litter was found above the high tide line and in the dunes/vegetation.

Discussion: It is assumed that winds eventually blow most marine debris items including balloons and ribbons toward the highest portion of the beach where it becomes trapped by dune vegetation. As this area is critical for nesting birds, diamondback terrapins and sea turtles, balloon litter concentrated in this area poses an increased threat of entanglement.

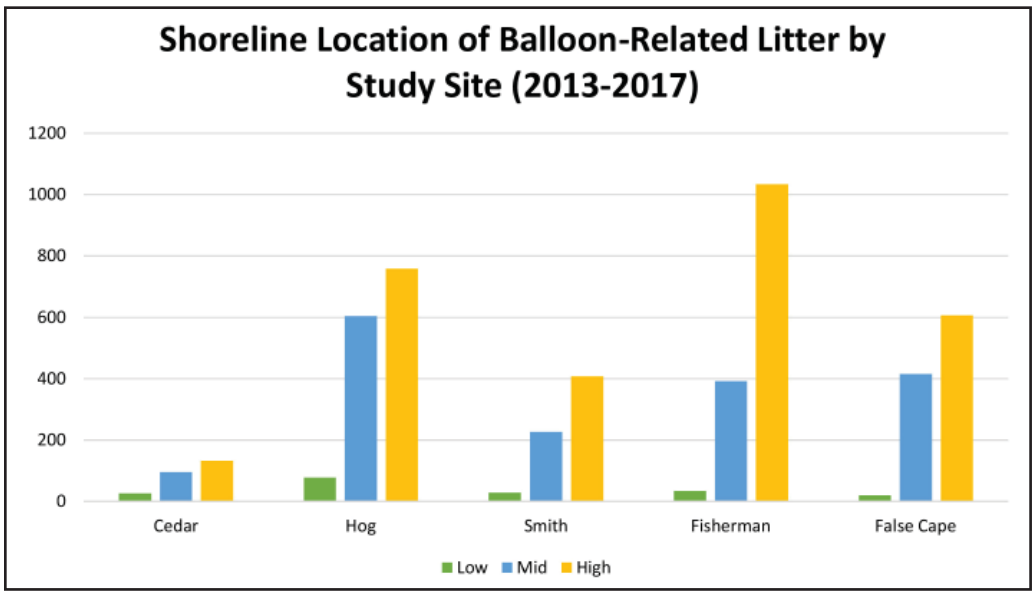


Figure 53: The majority of balloon-related litter was found above the high tide line and in the dunes/vegetation at each study site.

Seasonality of Balloon Litter

In the 43 surveys with GPS data, we recorded 1,359 balloon-related litter items in winter months (December 21 to March 20), 5,555 in summer (June 21 to September 20) and 3,983 in fall (September 21 to December 20). No spring surveys were conducted (Table 11).

We wondered if there were significant interactions between our five study sites, our balloon litter counts, and the three seasons in which we surveyed. We attempted an analysis of our data sets using a two-way ANOVA statistical test, but determined that we do not have enough observations to run a two-way ANOVA. Other statistical tests indicate that a potential greater number of balloons per linear mile were found in the fall as compared to the summer and winter, which showed no difference in means. Dr. Leigh Lunsford, who ran the tests, suggests that more data and more consistent data collection may resolve this in the future. See Appendix G for more information about the statistical analysis of our data regarding seasonality.

Location	Season	# of Surveys	Total Miles Surveyed	Total Pieces of Balloon-Related Litter	Average Pieces of Balloon Litter Per Mile
Cedar Island	Winter	3	9.25	245	26.5
Cedar Island	Fall	3	11.8	577	48.9
False Cape	Summer	4	14.9	721	48.4
False Cape	Fall	5	7.2	1,598	221.9
FINWR	Winter	4	6.5	773	118.9
FINWR	Summer	3	2.9	789	272.1
FINWR	Fall	5	4.8	1,310	272.9
Hog	Summer	9	34.8	2,946	84.7
Hog	Fall	1	3.1	251	81.0
Smith	Winter	3	4.8	341	71.0
Smith	Summer	2	10.75	1,099	102.2
Smith	Fall	1	0.25	247	
	Totals	**43**	**111.1**	**10,897**	

Table 11: During 43 of our surveys that had GPS data, a total of 10,897 pieces of balloon-related litter were recorded.

Latex balloons and pieces outnumbered foil balloon litter in six of the nine months in which surveys were conducted (Figure 54).

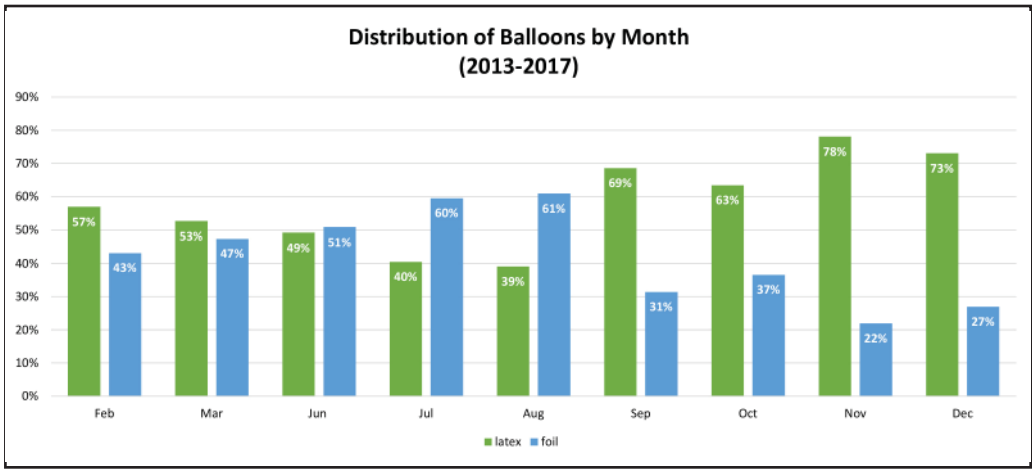


Figure 54: Distribution of latex and foil balloons by month.

In terms of condition of balloons, trends are similar by month with most latex balloons found in a burst condition and most foil balloons deflated (Figure 55). The condition of balloons found in winter months (Dec. and Feb.) is slightly different with most latex balloons recorded as latex nubs.

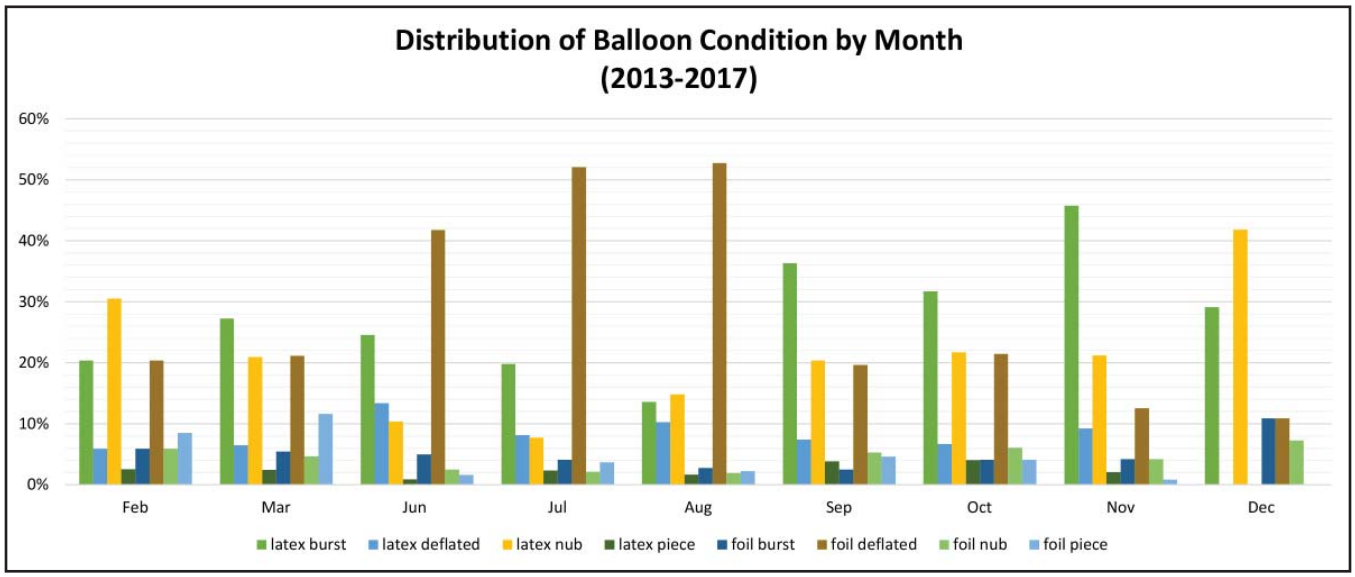


Figure 55: Relative abundance of balloon litter condition by month.

Seasonality of Event and Greeting Balloons

We were unable to determine seasonal trends in overall types and quantities of balloons, but we detected a seasonal relationship for certain types of balloons including Valentine's Day, Mother's Day, Father's Day and graduation balloons which are more commonly found littered in late spring through summer. For instance, Mother's Day occurs in May in the US, and we found Mother's Day balloons mostly during June, July and August (Figure 56). And while graduation events could occur year-round, graduation balloons are mostly found June through August, a time when most high school and college students graduate (Figure 57). Finally, balloons imprinted with words of 'Congratulations' may be appropriate year-round, yet these types of balloons were recorded with greatest frequency June through August, perhaps indicating their association with graduations as well.

A total of 25 Valentine's Day balloons were recorded during our surveys, the majority of which were

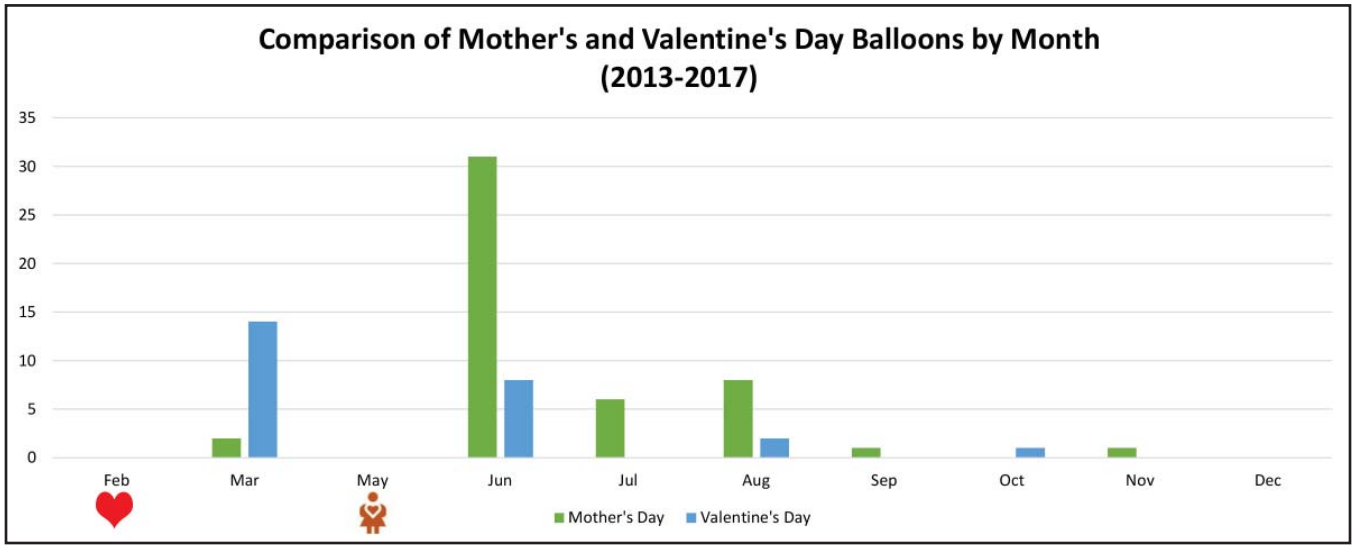


Figure 56: Records of Mother's Day and Valentine's Day balloons by month.

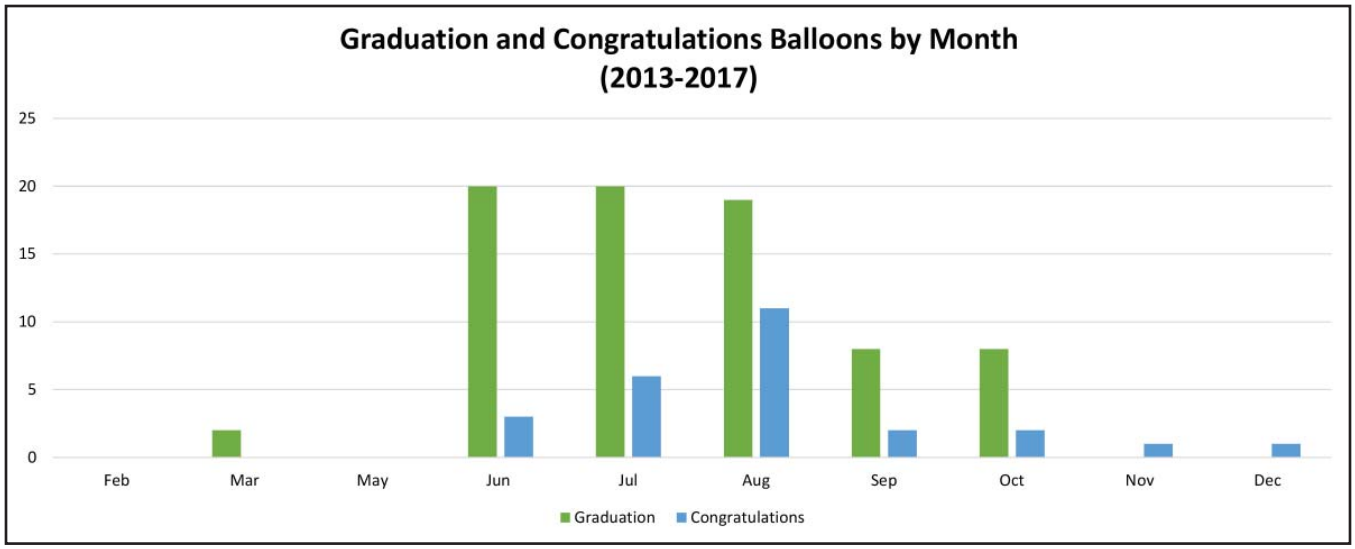


Figure 57: Records of Graduation and Congratulation balloons by month for months surveys were conducted.

found in March. After Mother's Day (the second Sunday in May), 47 Mother's Day balloons were found on the beaches in our study sites, the majority of which were found in June.

Comparison of Balloon Litter vs. Other Types of Marine Debris

During ten of our surveys, we brought volunteers with us to record other marine debris items found within the survey area while we recorded only balloon-related litter. While balloon litter was removed from the survey areas, other marine debris was only recorded and left in place due to the logistical challenges of removing it. Therefore, balloon litter recorded was new accumulation between surveys while other marine debris would be considered a standing stock accumulation.

In the following figures (Figures 58-67), the most frequently found litter items are listed in addition to the figure for all balloon-related litter. In many of our surveys, balloon-related litter was the most frequent type of identifiable litter recorded. Balloons and ribbons-only were recorded as separate items for this analysis but still remained as two of the top ten debris items recorded. Balloons were the most recorded item on Cedar and Hog Islands as well as one of the Smith Island surveys. When all items were added together for a top ten analysis for all ten of these surveys, balloon-related litter was the most frequent item recorded at 40% (N=2,771) of debris items. Plastic bottles came in second at 22% (N=1,544) (Figure 68).

Discussion: While all types of marine debris are cause for concern, the amount of balloon litter compared to other types of debris was unexpected. Data collected for the ICC in Virginia rarely places balloons in the top ten items recorded. It is interesting that when looking at the more remote beaches of Virginia, balloons and/or balloon ribbons are almost always in the top three. For the most part, these sites are relatively untouched by humans so we can assume that, like the balloons, all of the marine debris recorded floated in from the ocean or the Chesapeake Bay.

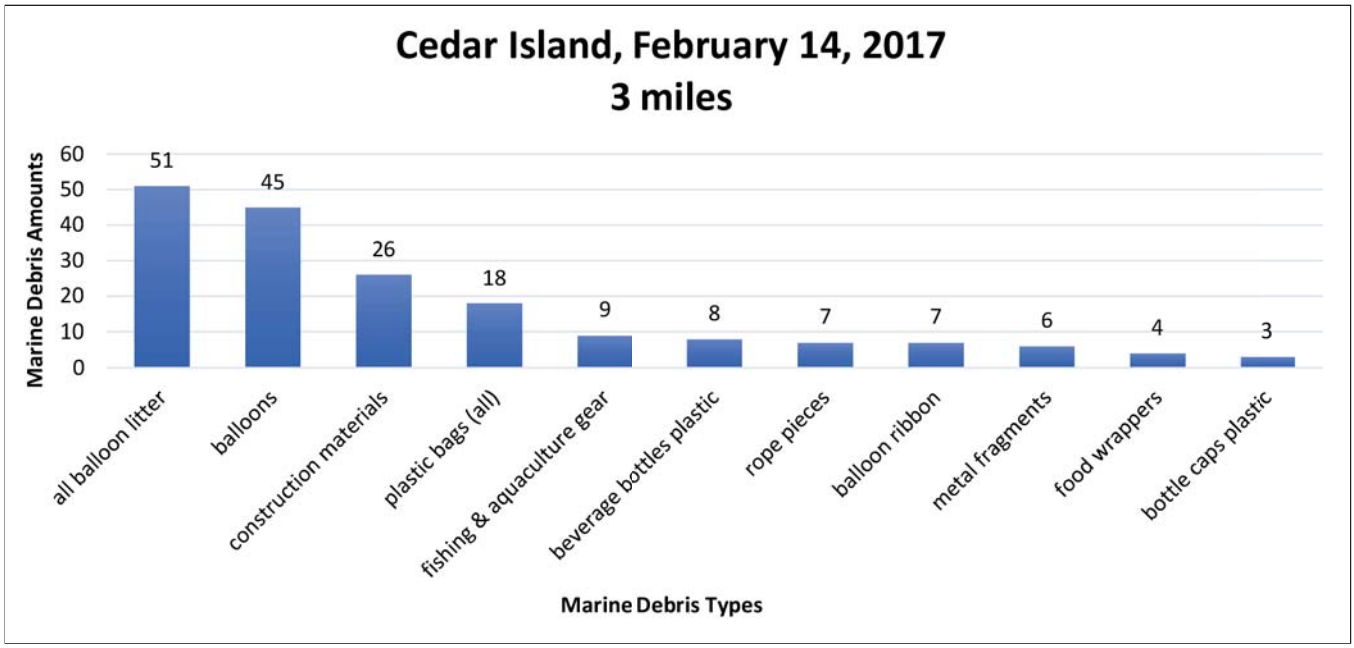


Figure 58: Most frequently recorded marine debris items during a 3 mile survey of Cedar Island on February 14, 2017.

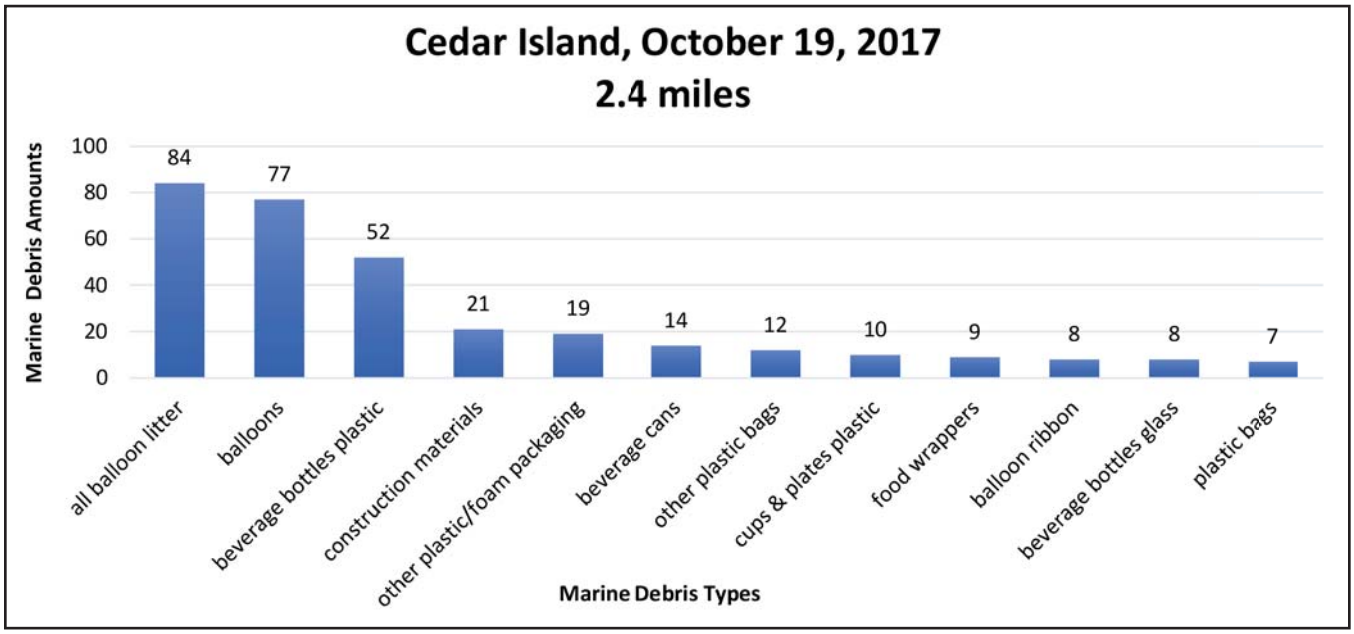


Figure 59: Most frequently recorded marine debris items during a 2.4 mile survey of Cedar Island on October 19, 2017.

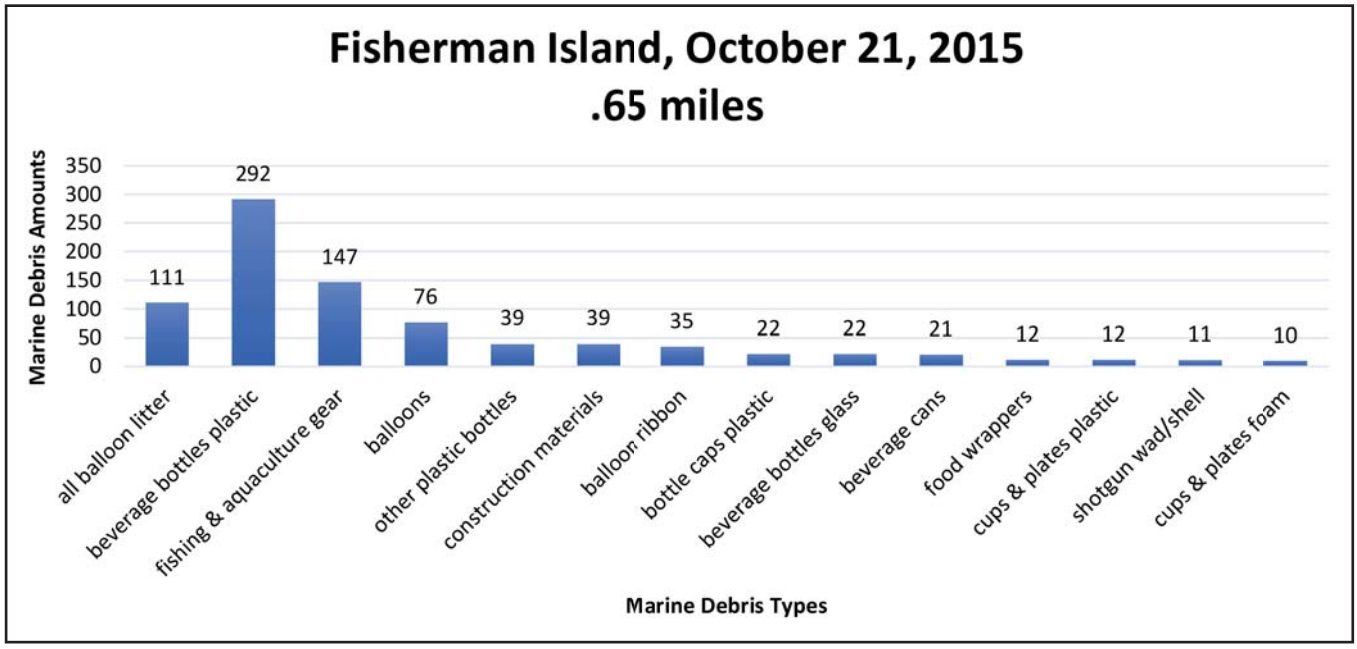


Figure 60: Most frequently recorded marine debris items during a .65 of a mile survey of Fisherman Island on October 21, 2015.

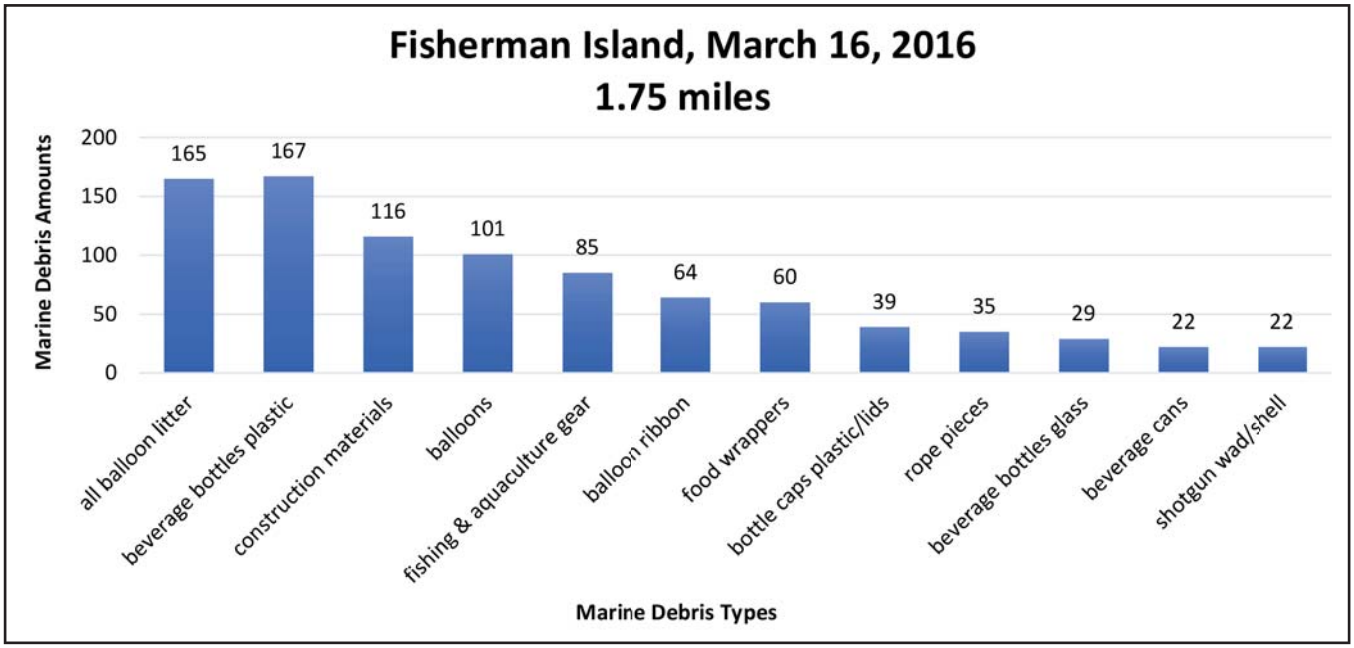


Figure 61: Most frequently recorded marine debris items during a 1.75 miles survey of Fisherman Island on March 16, 2016.

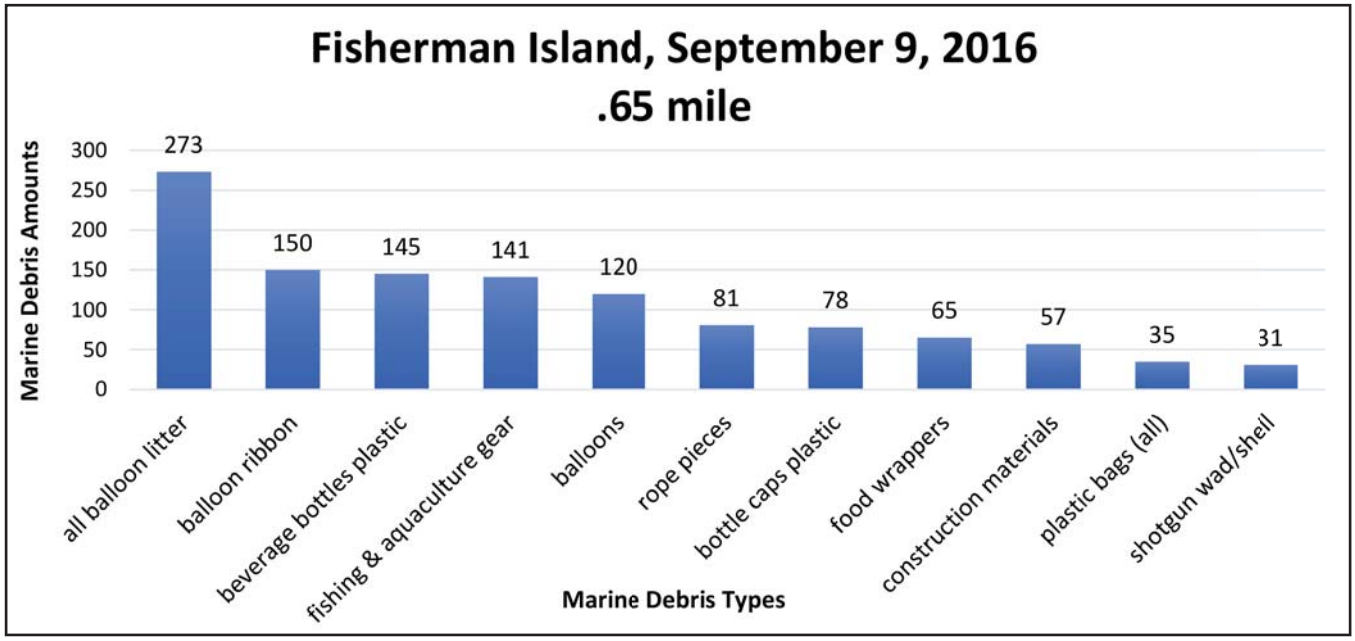


Figure 62: Most frequently recorded marine debris items during a .65 of a mile survey of Fisherman Island on September 9, 2016.

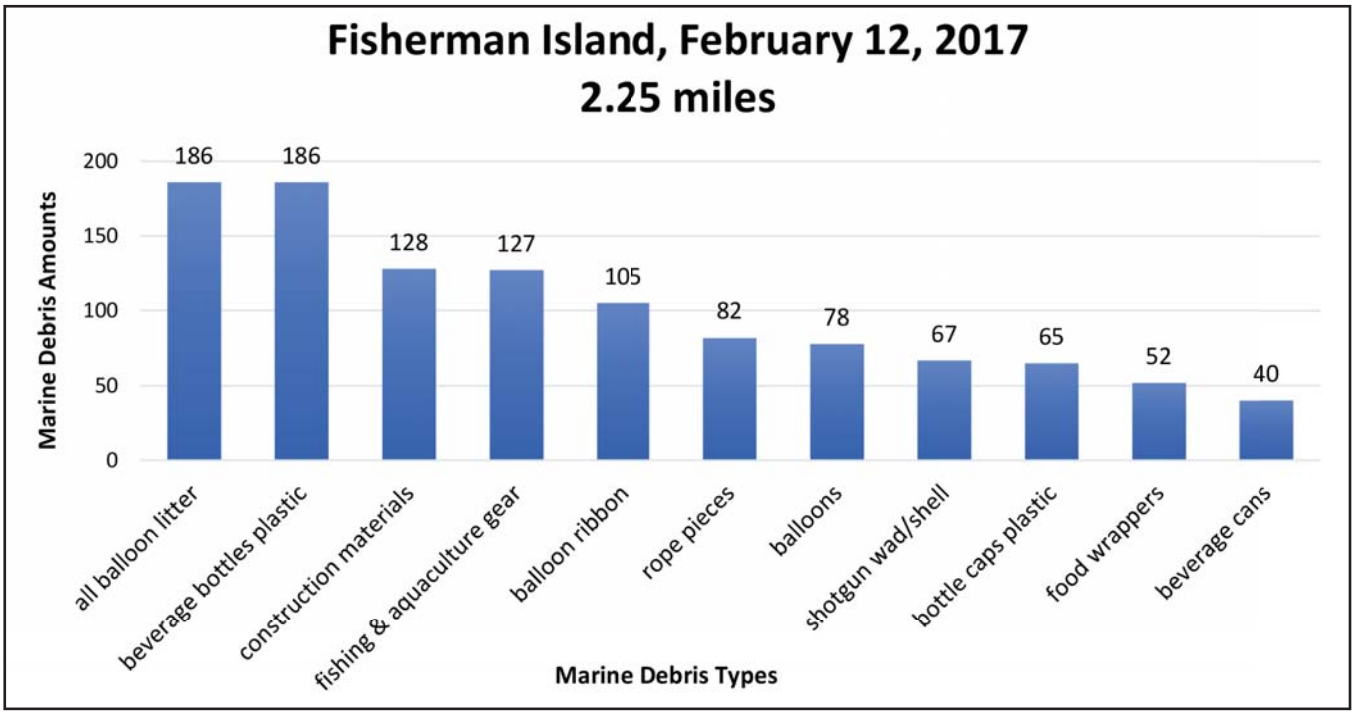


Figure 63: Most frequently recorded marine debris items during a 2.25 miles survey of Fisherman Island on February 12, 2017.

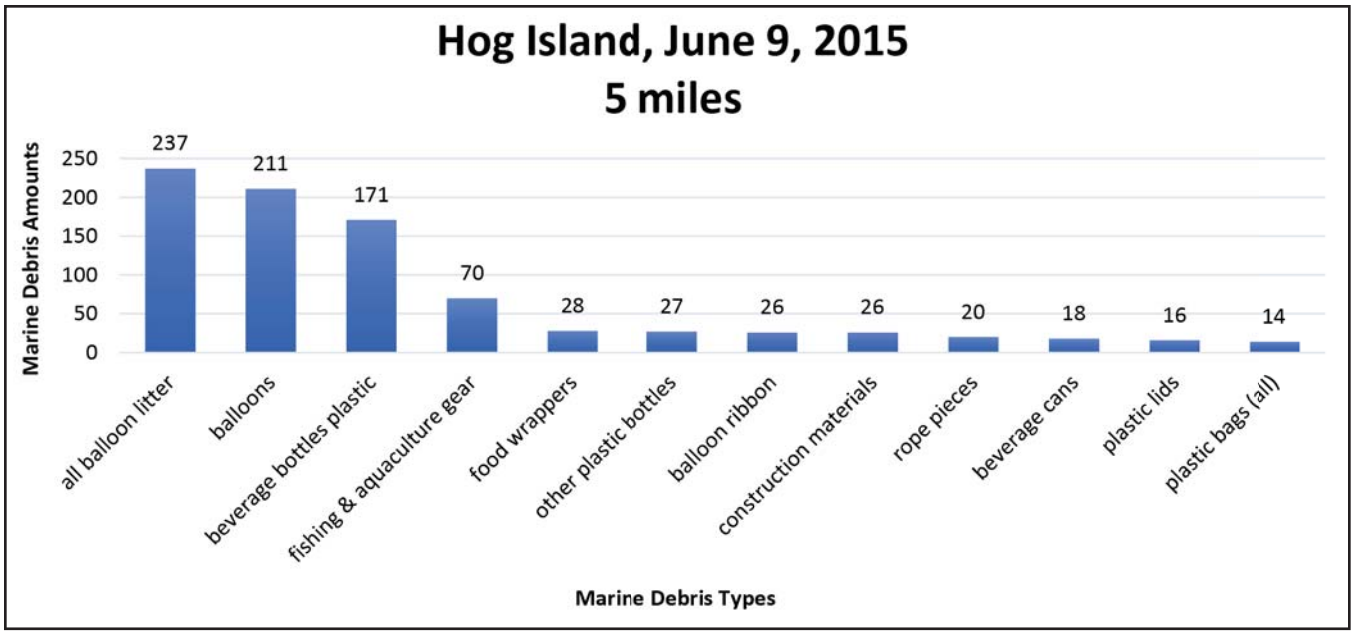


Figure 64: Most frequently recorded marine debris items during a 5 mile survey of Hog Island on June 9, 2015.

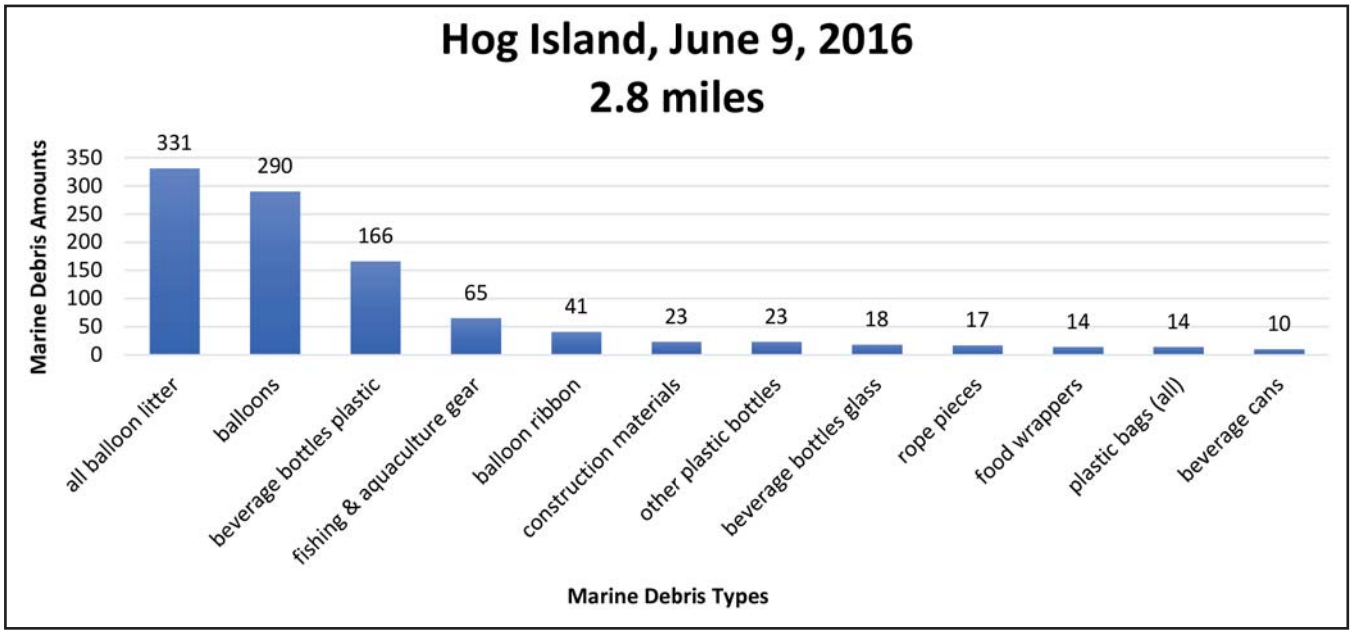


Figure 65: Most frequently recorded marine debris items during a 2.8 mile survey of Hog Island on June 9, 2016.

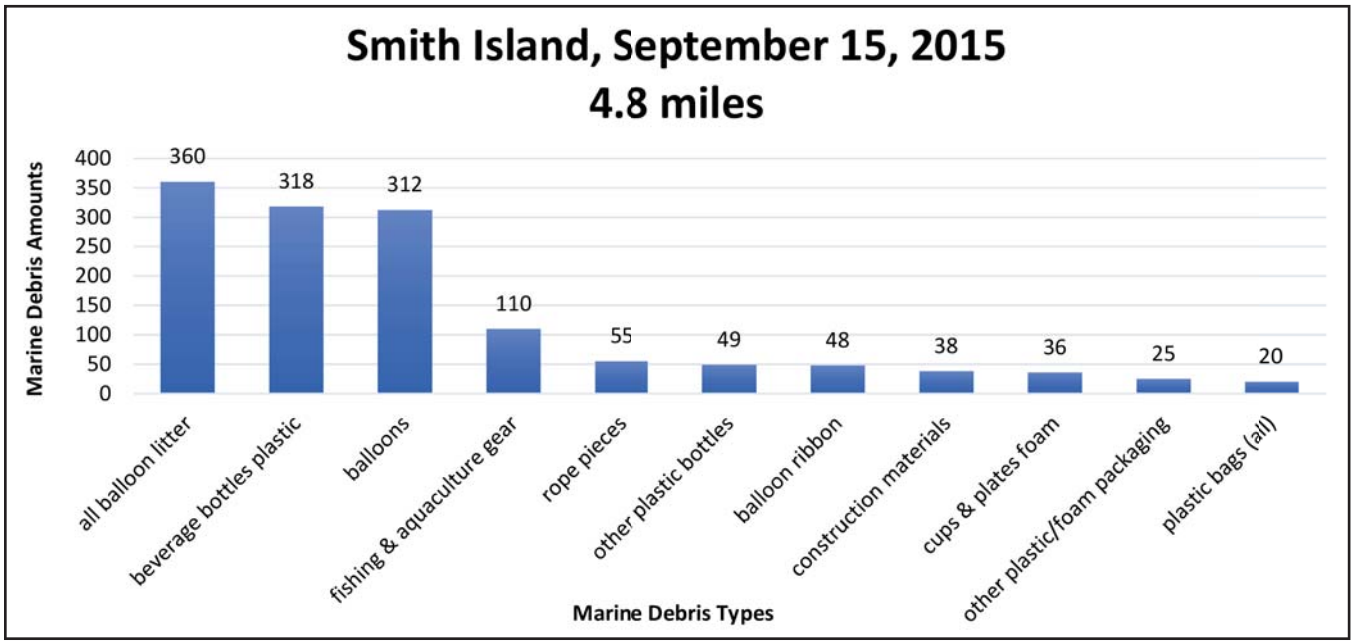


Figure 66: Most frequently recorded marine debris items during a 4.8 mile survey of Smith Island on September 5, 2015.

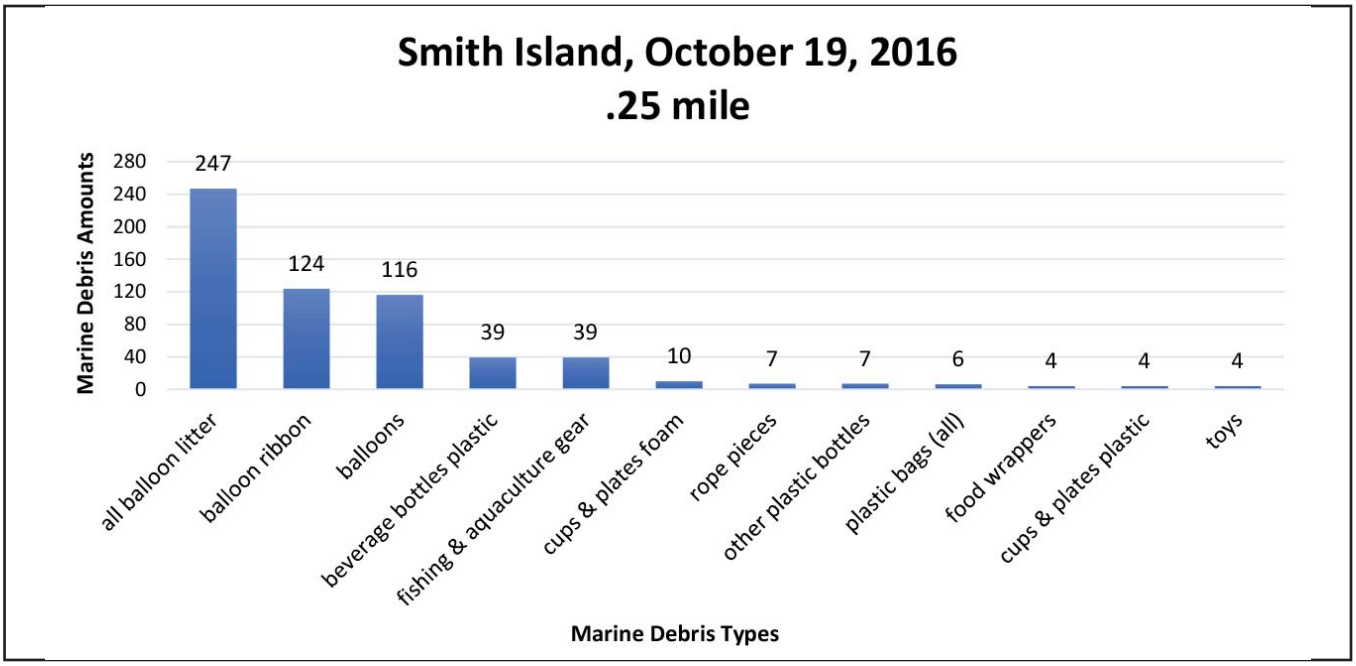


Figure 67: Most frequently recorded marine debris items during a .25 mile survey of Smith Island on October 19, 2016.

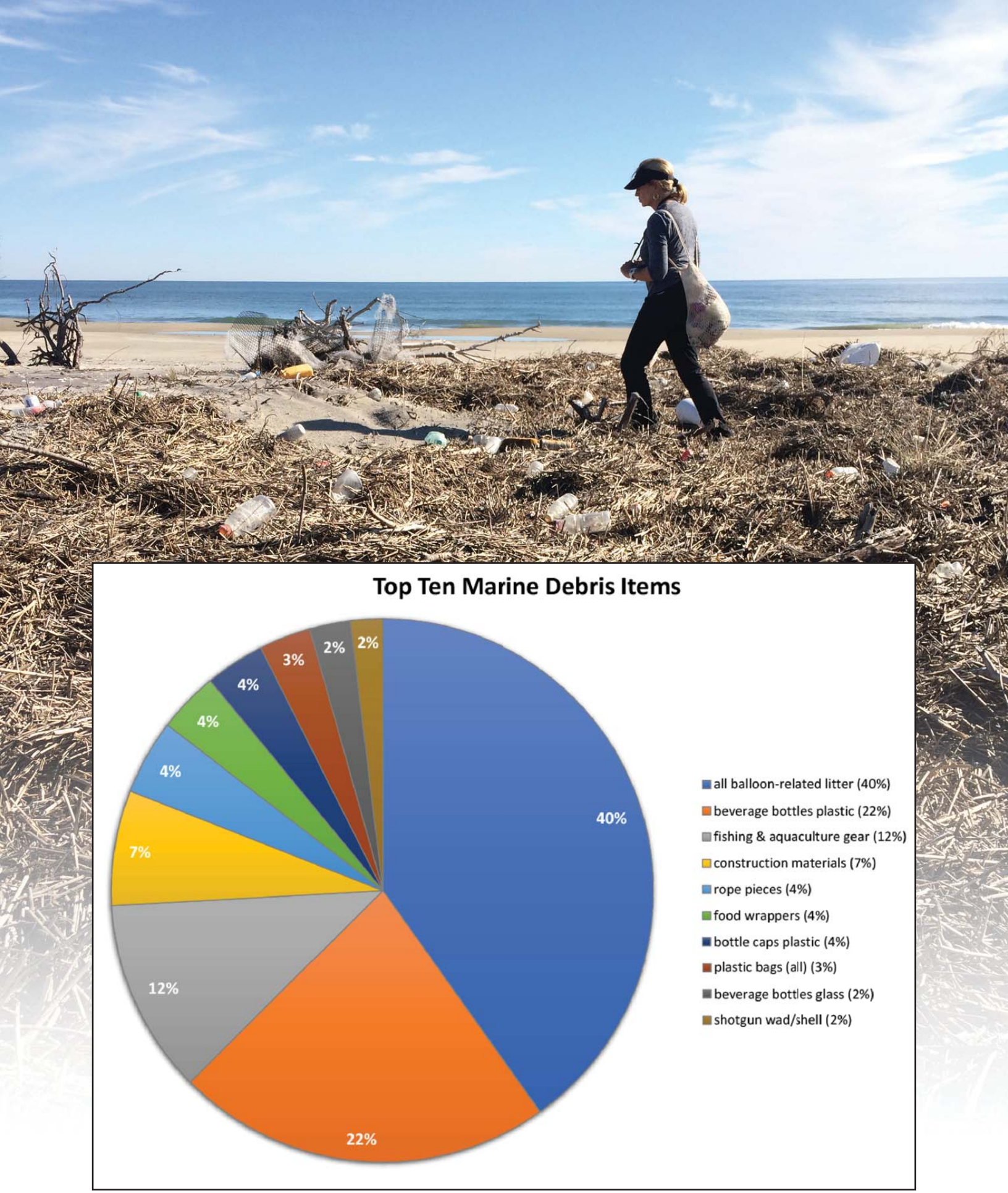


Figure 68: Most frequently recorded marine debris items during ten surveys.

OTHER FINDINGS

OTHER FINDINGS

Other Unusual Finds Along the Way

As of November 2017, we surveyed 111 linear miles of ocean/bay-front over the course of five years. During this time, in addition to recording information on balloon litter, we have come across some more unusual items of marine debris worthy of note.

On March 16, 2015, during a survey of Fisherman Island, a small box caught our attention. It was wrapped with white athletic tape with a black symbol stenciled on top (Figure 69). The box contents included a small dry-bag containing a cassette tape and three pieces of paper: one listing 30 codes and constellations; one printed with a circular chart with rings and letters; and one additional piece of paper with 12 circular colors in a vertical line. The tape recording was of a man speaking about his philosophical beliefs.

Figure 69: An unusual find during a survey of Fisherman Island on March 16, 2015.

The following year, on March 17, 2016 we found a note in an old glass Pepsi bottle on Hog Island. The bottle had a metal cap, tightly sealed. The paper note inside was well preserved and read as follows (actual and not corrected for spelling) (Figure 70):

"Dear Friends,

We threw this bottle of the jettie on Aug 12, 1979 on the of Cape May Pt. Please write back where and when you found this bottle you name. Our address is and names: Joie and Corey, p/o Box 248, Cape May Point, NJ, 08212. OVER-->

(this is on back) This is for a school project. From, Joie Anne + Corey Smith ages 12 + 12"

With the date of 1979, this would make the note (and bottle) 37 years old when it was

Figure 70: A message in a bottle from 1979 found during a survey of Smith Island on March 17, 2016.

found in 2016 and the individuals that wrote the note would now be over 50 years old. We plan to research this note further.

More recently, after completing a survey on September 5, 2017 at False Cape State Park near the Virginia/North Carolina border, we came across a colorful wrack line at the water's edge, north of our study area. Upon closer inspection, we observed seaweed and other natural debris entangled with multiple pairs of plastic swim goggles and sunglasses in a variety of colors and styles. This patch of debris stretched for about 50 feet. We stopped to collect and record this debris and counted 29 pairs of goggles, 17 pairs of sunglasses, several plastic wristbands, and a barnacle-encrusted hat embroidered with "SOVA Special Olympics Virginia" (Figure 71). Whether any of these items are interrelated, we cannot be certain.

Figure 71: Sunglasses and goggles found in the wrack line at False Cape State Park. Photos by Kathy O'Hara.

Observations of Wildlife Interactions with Balloon Litter

During the course of this study, observations were made of wildlife interactions with balloon-related litter. On several occasions, we encountered northern diamondback terrapins during nesting activities on our barrier island sites. These turtles were often seen in the highest areas of the beach where the majority of balloon litter is concentrated. While we did not observe any direct contact of these turtles with balloon litter, our observations raised questions as to the potential for entanglement of these turtles during nesting activities. In another incident, we discovered turtle "crawl" tracks in the sand leading to the nest of a loggerhead sea turtle on Hog Island in July 2015. (Figure 72). In this case, we found a round plastic disk in the turtle's track. The disk was a device from a "Singing Balloon" (which plays a song). While the sea turtle had apparently crawled over the disk, its tracks did not appear impeded. If this had been a bunch of balloons and/or ribbons the outcome could have been different.

Figure 72: Loggerhead sea turtle tracks on Hog Island, July 13, 2015. The arrow points to a singing balloon disk.

SUMMARY OF FINDINGS

Summary of Findings

The large amount of balloon-related litter recorded on Virginia's remote beaches is of concern especially in these areas designated for protecting wildlife. Most of this litter accumulates on the highest portions of the beach, which is critical habitat for nesting sea turtles and diamondback terrapins, birds, and other wildlife. In many cases, balloons and plastic ribbons are not only prevalent, but have been counted as the most abundant type of marine debris as compared to other debris items on remote beaches of Virginia.

In examining the variables "Site Name," "Season," and "Balloons per Linear Mile," we see a potential trend (i.e., a not quite significant result) that the mean number of Balloons per Linear Mile could be larger in the fall than in the summer and winter (i.e., there may be a seasonal effect). We also note that Fisherman Island and False Cape tend to collect more balloons per linear mile, on average, than the other locations (i.e., there appears to be a Site effect). We strongly emphasize that these are preliminary results. Due to small sample sizes, we did not conduct a two-way ANOVA to test for an interaction between Site and Season.

Latex balloons are the most common type of balloon litter found in our study, and most latex balloons found on Virginia's remote beaches are in a burst condition. Foil balloons are commonly found deflated on Virginia's remote beaches.

The balloon industry claims latex balloons are biodegradable, and therefore safe for releases. Our finding of latex balloons attached to a foil "Happy Holidays" balloon in July suggests that they may have persisted in the environment for seven months. Regardless, there are currently no studies that correlate balloon longevity with threats posed to marine wildlife. One could assume the longer a latex balloon lasts in the marine environment, the greater the likelihood that it will pose a threat.

The prevalence of plastic ribbons on Virginia's remote beaches is one of the more unexpected findings of this research. Most ribbons recorded were attached to latex balloons. Since the balloon industry recommends not tying ribbons to balloons intended for release, it appears that either consumers are not abiding by these recommendations, or most of the latex balloons we are finding are not from mass releases. For foil balloons, plastic ribbons are usually not tied but attached with tape. This could make ribbons more likely to fall off foil balloons in the marine environment and possibly account for our many findings of plastic ribbons without attached balloons, or "ribbons-only." All ribbons pose threats of ingestion and entanglement for wildlife. Ribbons wrapped around dune grasses and other plants may have additional negative impacts on coastal vegetation.

Weather balloons and their parts found primarily at our barrier island sites may have come from several National Weather Service facilities in Virginia or other states where balloons are released. While we cannot be certain of the origin of any of our weather balloon findings at this time, further investigation of markings on these weather balloons may lead to information on their origin.

Anecdotal observations of wildlife interactions with balloon litter include northern diamondback terrapins and a loggerhead sea turtle, both of which are protected species. Findings of Atlantic ghost crab interactions with balloons may suggest that foil balloons alter the temperature of sand surface areas or provide another benefit such as shelter or protection from predators. The observation of possible thermal impacts of foil balloons or other benefits on beaches is previously undocumented. Further studies of these observations and environmental impacts are recommended.

Balloon litter is a unique form of marine debris as it is often pre-planned and intentional. Several foil balloons found with handwritten memorial messages demonstrates this intent. The abundance of balloons with generic greetings and messages (Happy Birthday, Happy Valentine's Day, etc.) suggests that, while mass releases of balloons may be a source of balloon litter, the actions of individuals may contribute significantly. According to the current law in Virginia, it is legal to release up to 49 balloons in a one hour period. Hence, releasing a few "Happy Birthday," "Happy Valentine's Day," and "Congratulations Graduate" balloons in Virginia is not in violation of current law.

In aggregate, balloons and ribbons-only were found to be the most common marine debris items on remote beaches. In a sampling of 10 surveys where volunteers collected litter information, balloon-related litter accounted for 40% of all marine debris items recorded. Due to the site locations and infrequency of human presence on these sites, it can be assumed that all debris items washed in from the ocean or Chesapeake Bay which speaks to the volume of balloons floating in our bays, coastal waters, and ocean.

Speculation as to why latex balloons are most often found includes that latex are less expensive than foil balloons, bought in larger quantities, and are the preferred choice for mass balloon releases. The fact that foil balloons with generic shapes, characters and greetings comprise a large percentage of balloon litter may suggest individual actions (releases) contribute significantly to the balloon litter problem.

While it is not possible to determine the events leading to the release of any balloons found in our study at this time, specific types of balloons could provide clues to sources of balloon litter. For example, the abundance of graduation balloons in late summer points to the need for an awareness campaign targeted at students and school communities. Foil balloons with handwritten messages to loved ones demonstrates the need to involve funeral homes and other venues where memorials are

carried out in these outreach efforts. These personalized messages may also suggest that balloons were released at private memorials.

Findings on seasonality of specific types of balloons could also be useful in identifying not only target audiences, but also the appropriate timing for public awareness or social marketing campaigns. Consistent sampling at all study sites during the same months will need to be conducted to better understand these findings.

CONCLUSIONS

Conclusions

Our findings from five years of research demonstrate that balloon-related litter is of concern and in need of further research as well as reduction efforts. We hope that by continuing this research we will not only help provide information that will be useful to those who are working to prevent this form of marine debris, but will also provide a means to monitor the success over time of efforts to prevent the release of balloons.

Widespread behavioral changes are necessary to prevent balloon releases. Behavioral change can come from raising awareness through education; social marketing campaigns targeting key audiences; policies at schools, parks, houses of worship, and other places where balloon releases are likely to take place; and laws that ban the mass releases of balloons. This includes informing businesses and organizations that the balloons they use for advertising are being found on remote beaches protected for wildlife. Companies that manufacture, distribute and sell balloons, or own the rights to balloon character images, could also be informed that their products are contributing to the balloon litter problem and be enlisted to support future efforts to decrease balloon litter.

The balloon industry is taking steps to reduce releases of balloons, especially foil and those with attachments. However, mass releases are still considered acceptable by the industry. This may give the general public the idea that if a mass release is acceptable by industry standards, any release is acceptable. We encourage the balloon industry to continue their efforts but perhaps more aggressively, in a manner that will ultimately reach more consumers to prevent intentional and accidental releases of all types of balloons.

Lessons Learned and Future Research

Identifying Audiences to Target Regarding Balloon Release Behavior

Data in this research could be used to identify key audiences who could be reached with a social marketing campaign or public education in order to influence changes in their behavior. For example, we identified the names of several companies that use balloons as part of their branding and marketing efforts including Kaleidoscope, Anagram, Chick-fil-A, Chuck E. Cheese, and Edible Arrangements. Real estate companies, retail stores, dental practices, fundraisers for charities, and weddings were also identified as sources of balloon litter. Balloons with business and organization names and/or logos provide important information on consumers of balloon merchandise. It is uncertain as to whether these entities are aware of the hazards caused by the release of balloons or that names are being "dropped" on protected beaches in Virginia. If these businesses and organizations were informed of our findings, it would be interesting to see if changes are implemented in their practice of using/distributing balloons and/or educating their customers.

Figure 73: A Burton and Burton balloon found on Hog Island in 2016. According to their website, they are "The World's Largest Balloon and Coordinating Gift Supplier®"

When available, we also recorded manufacturers and product numbers printed on foil balloon stems (Figure 73). Companies that manufacture, distribute, and use balloons, or own the rights to balloon character images, could be enlisted to support future efforts to decrease this source of marine debris.

Weather Balloons

Since NOAA's National Weather Service is a large purchaser of weather balloons, we encourage it to work with its vendors to create instruments (radiosondes, batteries, radio transmitters) and packaging (usually foamed plastic) to be made of materials that would be less harmful in the marine environment.

Continued Investigations on Balloon Litter

In order to further investigate variability between study sites, and seasonal fluctuations in amounts, types, and condition of balloon litter, surveys would need to be conducted at the same time of year for all sites. Findings on possible seasonality of specific types of balloons may be useful in identifying future target audiences and timing of social marketing and public awareness campaigns.

It is our hope that others working on this issue may be interested in conducting research similar to ours. Not all researchers may be able to spend an entire day or two counting balloon litter. We intend to use our lessons learned to develop a protocol (including data collection and analysis) for conducting this research on more consistent area to be sampled at each site requiring less time yet collecting valuable and valid information. As our methodology has been modified over time, we have created a datasheet for both balloons and other debris noted and developed consistent methods of data collection and analysis for future research efforts.

A simplified protocol will allow for more frequent surveys to be conducted and will provide a more complete picture when determining trends in seasonality. Due to the nature of marine debris, any assumptions made from this data will be difficult to prove. For example, determining if the latex balloons we find originated from a mass release or an individual release may never be known.

As the *Virginia Marine Debris Reduction Plan* and the *Joyful Send-Off* community-based social marketing campaign continue to be implemented, our monitoring will be important to determine

if trends can be detected that would indicate the success of these programs over time. Regular monitoring can give us a sense of any increase or decrease in this type of litter as well as any change in trends as to the types and conditions of balloons being documented.

The premise that helium-filled balloons, like weather balloons, are more likely to end up in the ocean may be supported by an examination of U.S. weather balloon patterns. An analysis of weather balloon information available from the National Weather Service would contribute significantly to the overall understanding of how balloons travel after release, not only in Virginia, but nationwide and worldwide too. Future research could reveal if more balloons are found on east coast beaches as compared to the west coast, and also examine accumulation rates on the beaches of the Great Lakes.

An assessment of the relative abundance of balloons at sea as compared to other debris would be of interest. This in turn could further our understanding of the frequency of encounters with balloon-litter by marine wildlife. The type and number of marine species negatively impacted by balloons requires additional documentation and research. Anecdotal observations of coastal vegetation and ghost crab interactions with balloons raise questions about other negative environmental impacts of balloons in addition to the well-documented problems of ingestion and entanglement. Also, if further studies confirm that balloons are more likely to end up in the ocean, then the conclusion could be drawn that the marine environment and its inhabitants are more likely to be impacted by balloons than those on land.

The findings from this study have important implications from a management perspective. While balloons and their attachments are documented to present ingestion and entanglement threats to animals – especially sea turtles and seabirds – it is legal in most places to release large numbers of balloons into the atmosphere. Legislation to ban or limit balloon releases has been enacted in a few U.S. states, including Virginia. Schools, parks, cemeteries, and other venues could also have policies that prohibit all littering – including balloon releases. While state and local legislative initiatives are important, balloons travel beyond the boundaries of these laws. Serious consideration should be given to regional and even national social marketing campaigns and other efforts to address the problems caused by released balloons.

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Supplementary Data

Supplementary data associated with this report can be found on Clean Virginia Waterways' web site http://www.longwood.edu/cleanva/

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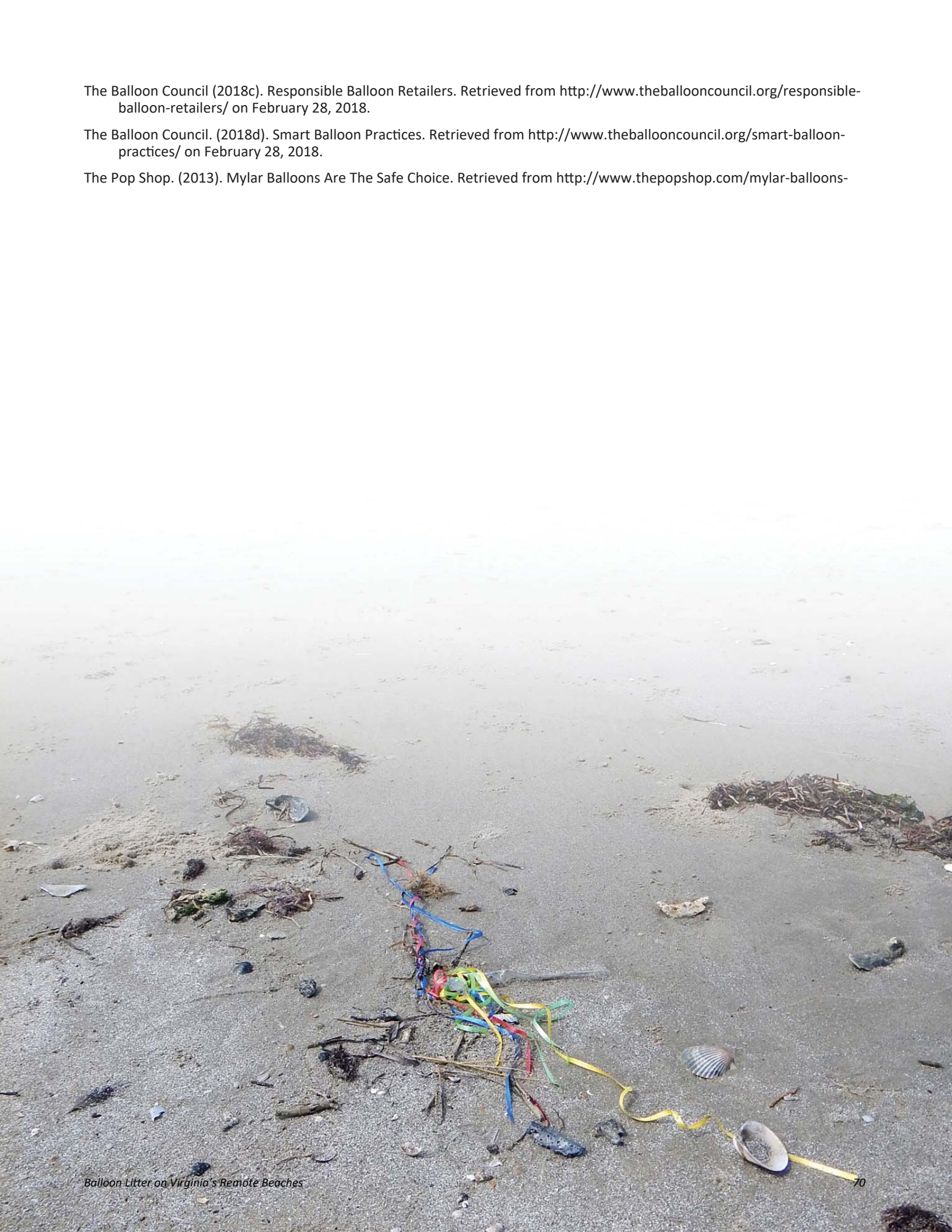

APPENDICES

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Appendix A: Balloon Council Letter to Virginia Senators

The Honorable Emmett Hanger, Jr.
P.O. Box 396
Richmond, VA 23218

Dear Chairman Hanger:

RE: SB 1107 Release of Balloons

The Balloon Council would like to express our opposition to SB 1107 in its current form. While we do not want to see any balloon release bans enacted, and no state has since Virginia did in 1991, Virginia already has a law on the books and it should be supported. The Balloon Council would support the **Virginia Senate Finance Committee** taking up the re-designation of the civil penalty for reasons highlighted below:

- **While some animals may chew latex balloons, researchers have found no credible evidence that balloons have ever caused the death of an animal.**

The enacted Virginia state law was initiated based on several factual inaccuracies about balloons and the environment, which led to many incorrect conclusions that have only caused harm to the many members of the state who sell balloons for their livelihood. **Further restrictions would only exasperate an already strained business climate**.

With all due respect to the bill sponsor, Senator McWaters, there are other individuals across this country and internationally who look to balloons as a source of healing. For example, there was the **Virginia Tech** release in memory of those killed and at **Sandy Hook Elementary School**, at least seven municipal fire departments gathered and raised 27 balloons and rang the service bell 20 times for each child slain and just last week **Pope Francis** ended a **Vatican** tradition of releasing doves for peace in St. Peter's Square, swapping in balloons. "Here's the balloons that mean, peace," Francis said, as children in the square released pink, purple, white and green balloons.

In addition, latex balloons are a fully biodegradable, 100 percent natural product made from the milky sap of the rubber tree. Latex is farmed in sustainable, ecologically friendly processes and the oxygen produced by the trees in the photosynthesis process is beneficial to the environment. In the manufacturing process the latex is colored with natural dyes. Research has demonstrated a latex balloon will degrade at approximately the same rate as an oak leaf.

Appendix A: Balloon Council Letter to the Virginia Senators (continued)

The Balloon Council, a national association of balloon manufacturers, distributors and retailers, has developed standards for balloon releases in order to minimize their impact on the environment. These guidelines recommend the use of self-tied, biodegradable balloons without attachments, including strings, plastic plugs or other weighted objects.

Balloon retailers across the nation have joined the Balloon Council's nationwide "Responsible Balloon Retailer" program. The retailers have committed to adhere to a code of smart balloon practices and proactively educate consumers about smart balloon use to ensure appropriate handling.

Based on the facts, Senator McWaters proposal is well-intentioned but misguided. **Hurting balloon sales would have no impact on the environment, but it would cause economic harm to the many people in Virginia who count on balloon sales for their jobs**.

Lorna O'Hara

Executive Director
The Balloon Council

Cc:

- Senator John Watkins [R-10]
- Senator Frank Ruff, Jr. [R-15]
- Senator Mark Obenshain [R-26]
- Senator Donald McEachin [D-9]
- Senator Chap Petersen [D-34]
- Senator Richard Stuart [R-28]
- Senator David Marsden [D-37]
- Senator Bill Stanley [R-20]
- Senator John Miller [D-1]
- Senator Adam Ebbin [D-30]
- Senator John Cosgrove [R-14]
- Senator Ryan McDougle [R-4]
- Senator Jennifer Wexton [D-33]
- Senator Lynwood Lewis [D-6]

The Balloon Council
Affirming America's
Ongoing Love Affair
with Balloons

Appendix B: Balloon Data Card with Visual Key to Balloon Conditions

Date: Location: Volunteers:

GPS	Latex/Foil/ Ribbon Only	Balloon Color/Shape	Ribbon/ Attach	Condition	Location on Beach	Other Notes
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	
	L F RO			B D N P	L M H	

Page_____ of _____

Appendix B: Balloon Data Card with Visual Key to Balloon Conditions (continued)

Latex Balloon Conditions

Burst

A burst balloon has reached an altitude at which it has popped, creating a shredded appearance.

Deflated

A deflated latex balloon is still in its whole state. It may still contain some helium or be completely deflated. They often have the appearance of being "melted."

Nub

A nub is the opening end of the ballon, usually knotted and it cannot be determined if that balloon burst or if the rest of the balloon has been separated.

Piece

A piece is usually the ring from the opening of the balloon or a shard, likely from a burst balloon.

Appendix B: Balloon Data Card with Visual Key to Balloon Conditions (continued)

Foil Balloon Conditions

Burst

A burst foil balloon appears ripped or blown apart.

Deflated

A deflated foil balloon is still in its whole state. It may still contain some helium or be completely deflated.

Nub

A foil balloon nub is the piece that is tied to the ribbon and/or the part of the balloon where the helium is filled.

Piece

A foil balloon piece can sometime be difficult to determined as being a foil balloon, especially when faded. We often look for a seam that is characteristic of how foil balloons are made.

Appendix C: Data Card for All Non-Balloon Litter

Location:	Date: Recorder:
6-pack holders	glass pieces
bags plastic	k-cups
beverage bottles glass	lightbulbs
	metal fragments
beverage bottles plastic	oil/lube bottles
	other plastic bags
	other plastic packaging
beverage cans	paper bags
	personal products
bottle caps metal	plastic lids
bottle caps plastic	plastic pieces (hard)
buoys, floats	
cigar tips	
cigarette Butts	plastic pieces (film)
cigarette lighters	
clam net	
clothing/shoes	rope pieces
construction materials	shotgun shell
	shotgun wad
crab baskets / crab pots	strapping bands
cups & plates foam	straws/stirrers
cups & plates paper	Take out containers
cups & plates plastic	tennis ball
fishing line	tobacco packaging
fishing lures, light sticks	toys
fishing net & pieces	utensils
foam pieces	
food wrappers	
food containers (hard plastic)	

Appendix D: Detailed Information on Balloons Found with Names and/or Logos

Name and/or Logo	Type of Balloon(s)	Number of Records	Number of Balloons
Chick-fil-A	Latex (4), Foil (2)	5	6
Chuck E. Cheese	Foil (4)	4	4
Coldwell Banker	Latex (1), Foil (9)	3	10
McDonald's	Latex (3)	3	3
Weichert Realtors	Latex (5)	3	5
Capital One	Latex	2	2
Farm Fresh	Latex (1), Foil (1)	2	2
Food Lion	Latex	2	2
Krispy Kreme	Foil	2	2
Walmart	Latex	2	2
Weis Dentistry "Their Smile Says It All"	Latex	2	2
AdvanceAmerica.net	Foil	1	1
All About Kids Pediatric Dentistry	Foil	1	1
Babies"R"Us	Foil	1	1
Burton and Burton "Happy Birthday"	Foil	1	2
Casey Chevrolet	Latex	1	1
Center Rink	Foil	1	1
Chesapeake Utilities	Latex	1	1
Chester Co., PA	Latex	1	1
Children's Miracle Network	Latex	1	1
CUA Alumni Association	Latex	1	1
Cumming Real Estate	Latex	1	1
DCPNI DC Promise	Latex	1	1
Dairy Queen	Latex	1	1
Douglas Elliman Real Estate	Latex	1	6
Elfant Wissahickon Realtors	Latex	1	1
Elliston Fire Department	Latex	1	1
EHH	Latex	1	1
Expert Tree Service	Latex	1	15
First Finish	Latex	1	1
Garnet Valley	Foil	1	1
General Electrical Services	Foil	1	2
Gourmet Burgers and Fries	Latex	1	1
HGG	Latex	1	1
H&R Block	Latex	1	1
Hometown Realty	Latex	1	1
J&T Wedding	Latex	1	6
National Karastan	Foil	1	1
Nissan	Foil	1	1

Appendix D: Detailed Information on Balloons Found with Names and/or Logos (continued)

Name and/or Logo	Type of Balloon(s)	Number of Records	Number of Balloons
One Nineteen West Main Restaurant	Latex	1	1
Pappasita Cantina	Latex	1	2
PC Richard and Son Est. 1909	Latex	1	1
Red, White and Barbeque (possibly Kroger)	Foil	1	1
Ruby Tuesday	Latex	1	1
Ryan Homes	Latex	1	4
SCNB Chicken & Baba	Latex	1	1
Sheehy VIP	Latex	1	1
Si Track	Latex	1	8
Solanco spray foam, 717-284-5635	Latex	1	1
St. Jude's Research	Foil	1	1
Star Patient	Latex	1	1
Straight Talk Wireless	Foil	1	1
13 News Now	Latex	1	1
T-Swim (Safe Swim)	Latex	1	1
Toyota	Foil	1	1
Walk to Cure Arthritis	Latex	1	2
Total		**75**	**123**

Appendix E: Messages Written on Balloons

Study Site	Date	Balloon Type	Balloon Description	Message	Type of Event or Greeting
Cedar	2014-10-31	Foil (1)	w/white ribbon	Hand drawn face	Unknown
Hog	2014-06-06	Foil (1)	pink w/white ribbon (deflated)	"Love Ya Mom"	Birthday
Hog	2015-06-09	Foil (1)	white star (#119) w/white ribbon (deflated)	“RIP, I miss you Susie”	Memorial
Hog	2015-06-09	Foil (1)	red w/white ribbon (deflated)	"RIP Lay"	Memorial
Hog	2015-07-13	Foil (1)	green star (#199) w/white ribbon (deflated)	"RIParadise. My baby I love you always Miss you so much"	Memorial
Hog	2017-08-16	Latex (1)	white (burst) attached with red yarn to a plastic coated paper cup	“Jim” with hand drawn face	Memorial
Hog	2017-08-25	Foil (1)	red round (deflated)	"SALE"	Sale
Smith	2014-08-11	Foil (1)	w/gold ribbon (deflated)	She's just away	Memorial
Smith	2015-09-15	Foil (1)	star (#121) (deflated)	"we miss you"	Memorial
Smith	2016-03-17	Foil (1)	pink heart (deflated)	"RIP Deandra I Love You 3-5-15"	Memorial
Smith	2016-03-17	Foil (1)	blue round w/white ribbon (deflated)	“Xmas Party 2015” with 12 names	Christmas
Smith	2016-10-19	Foil (4) Latex (3)	3 balloons and a cheetah print	Written on latex balloons 'Tiana (on purple balloon), Nigel (orange balloon), Taetae (pink balloon), HBD Cheetah (burst), HBD Mickey, HBD Blue and Yellow	Birthday
Smith	2017-03-23	Foil (1)	green star (#199) w/white ribbon (deflated)	"Lost without U + Chris! I know you guys are always with me!"	Memorial
Fisherman	2014-09-04	Foil (1)	balloon number 376 w/red and white ribbons	"We love n miss you, HBD John. I love you Jon"	Memorial
Fisherman	2017-11-06	Latex (1)	orange w/white ribbon (deflated)	"I Love You Michael, Love Your Brother Jayden"	Memorial
False Cape	2017-06-01	Foil (1)	green star (deflated)	"You seem like an awesome guy! Can't wait to see you in heaven!! Hope you are having a blast in Heaven! Luv Andre + Jennifer"	Memorial
False Cape	2017-06-01	Foil (1)	heart (deflated)	written "mad"	Unknown
False Cape	2017-09-05	Latex (1)	purple	long message	Memorial

Appendix F: Weather Balloon Findings

Study Site	Date	Shoreline Location	Description
Cedar	2014-10-31	Mid	Box, balloon, string
Cedar	2015-10-12	Mid	Parts, parachute, string
Cedar	2015-10-12	Not Noted	Box
Cedar	2017-10-19	Mid	2 boxes, parachute, string, balloon
Hog	2013-06-05	High	Box
Hog	2014-06-06	Mid	Balloon, box, string
Hog	2014-06-06	High	Box (Lockheed Martin)
Hog	2014-06-06	High	Box (Lockheed Martin)
Hog	2014-07-17	Low	Balloon, box, string
Hog	2014-07-17	High	Box, string
Hog	2015-06-09	Not Noted	Box (Sippican/Lockheed Martin)
Hog	2015-07-13	Mid	Balloon, box, string, parachute, bag w/envelope (NOAA)
Hog	2015-07-13	Not Noted	Box
Hog	2015-07-13	Mid	Box
Hog	2015-07-13	High	Box
Hog	2015-07-13	High	Box, string, balloon
Hog	2015-11-16	Not Noted	Box
Hog	2016-06-01	High	Weather balloon parts
Hog	2016-06-01	Mid	Balloon fragment
Hog	2016-06-09	Low (in water)	Balloon, string, parachute
Hog	2016-06-09	High	Partial box
Hog	2016-06-09	High	Box
Hog	2017-08-25	High	Not noted
Smith	2013-07-25	High	Box (1492-540)
Smith	2014-08-11	Mid	Balloon
Smith	2015-09-15	High	Box, string, parachute
Smith	2015-09-15	High	Box, string, balloon
Smith	2016-03-17	High	Box
Fisherman	2014-09-04	Low (in tree)	Parachute, balloon, string, pc. from box
Fisherman	2014-09-04	Mid	Box
Fisherman	2014-12-05		
Fisherman	2015-09-11	High	String, zip ties
Fisherman	2016-10-12	Mid	Balloon, box, string, parachute, 6A31954
False Cape	2014-09-26	High	Box, string, balloon
False Cape	2016-11-03	High	Box

Appendix F: Weather Balloon Findings (continued)

Weather balloon findings examples: (clockwise from top left) A Lockheed Martin radiosonde box; A radiosonde box attached to a large latex balloon with cotton string; A NOAA National Weather Service balloon including box, string, balloon, parachute and plastic return envelope; A radiosonde box with a latex balloon piece and many feet of cotton string.

Appendix G – Statistical Analysis Notes

Preliminary Analysis of Balloon Litter Data

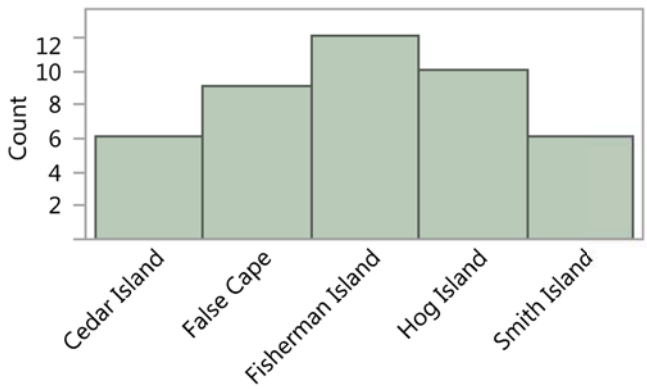
by Dr. M. Leigh Lunsford, Longwood University

Overall Summary: In examining the variables Site Name, Season, and Balloons per Linear Mile, we see a potential trend (i.e. a not quite significant result) that the mean number of Balloons per Linear Mile could be larger in the Fall than in the Summer and Winter (i.e. there may be a seasonal effect). We also note that Fisherman Island and False Cape tend to collect more balloons per linear mile, on average, than the other locations (i.e. there appears to be a Site effect). We strongly emphasize that these are preliminary results. Due to small sample sizes, we did not conduct a two-way ANOVA to test for an interaction between Site and Season.

Details:

Below we have descriptive statistics for each of the variables Site Name, Season, and Balloons per Linear Mile. Of note are the two extremely large outliers in the Balloons per Linear Mile distribution.

Site Name

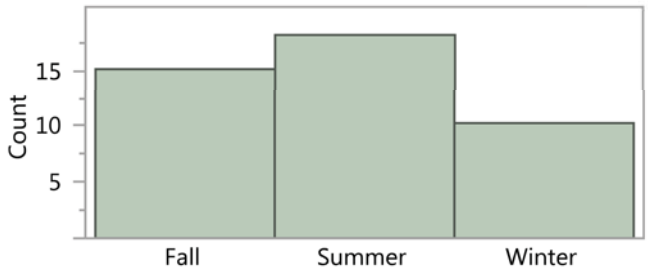


Frequencies

Level	Count	Prob
Cedar Island	6	0.13953
False Cape	9	0.20930
Fisherman Island	12	0.27907
Hog Island	10	0.23256
Smith Island	6	0.13953
Total	43	1.00000

N Missing 5
5 Levels

Season



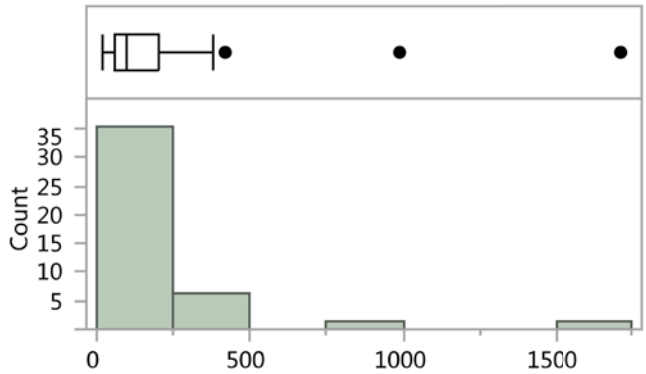
Frequencies

Level	Count	Prob
Fall	15	0.34884
Summer	18	0.41860
Winter	10	0.23256
Total	43	1.00000

N Missing 5
3 Levels

Appendix G – Statistical Analysis Notes (continued)

Balloons per Linear Mile



Quantiles

100.0%	maximum	1713.33
75.0%	quartile	203
50.0%	median	100.25
25.0%	quartile	58.55
0.0%	minimum	19.12

Summary Statistics

Mean	192.14163
Std Dev	289.34205
Std Err Mean	44.124248
Upper 95% Mean	281.18797
Lower 95% Mean	103.09529
N	43

From the tabulation below, we see we do not have enough observations to run a two-way ANOVA with the current levels of the explanatory variables Site Name (5 levels) and Season (3 levels). It is recommended that more observations are made to run a two-way ANOVA for these variables or to combine levels (for instance combine Cedar Island and Smith Island into one category). Some contextual knowledge may be helpful here in deciding how to combine these categories.

Number of Observations by Levels of Explanatory Variables.

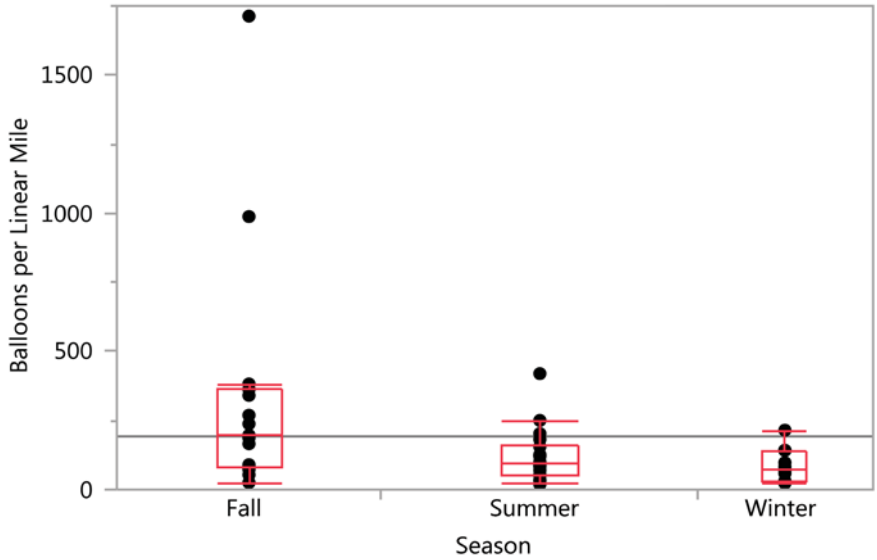
	Season			
Site Name	**Fall**	**Summer**	**Winter**	**All**
Cedar Island	3	0	3	6
False Cape	5	4	0	9
Fisherman Island	5	3	4	12
Hog Island	1	9	0	10
Smith Island	1	2	3	6
All	15	18	10	43

We will instead run two one-way ANOVAs to compare the mean number of Balloons per Linear Mile by Site Name and also by Season.

We start with the Season variable. Below is our output including all observations. While there is a significant result (i.e. there at least one different mean Number of Balloons per Linear Mile for the Seasons) we are very cautious about it. First the large outliers in the Fall greatly effect these results and negate the common standard deviation among groups assumption necessary for robust ANOVA results. Second, post-hoc analyses via the paired student-t tests show the Fall mean is significantly higher than the Summer and Winter means, which are not significantly different. However, the more conservative Tukey-Kramer HSD shows no significant difference among any of the means.

Appendix G – Statistical Analysis Notes (continued)

Oneway Analysis of Balloons per Linear Mile By Season



Missing Rows 5

Oneway Anova

Summary of Fit

Rsquare	0.154509
Adj Rsquare	0.112234
Root Mean Square Error	272.6219
Mean of Response	192.1416
Observations (or Sum Wgts)	43

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Season	2	543282.0	271641	3.6549	0.0348*
Error	40	2972908.4	74323		
C. Total	42	3516190.4			

Std Error uses a pooled estimate of error variance

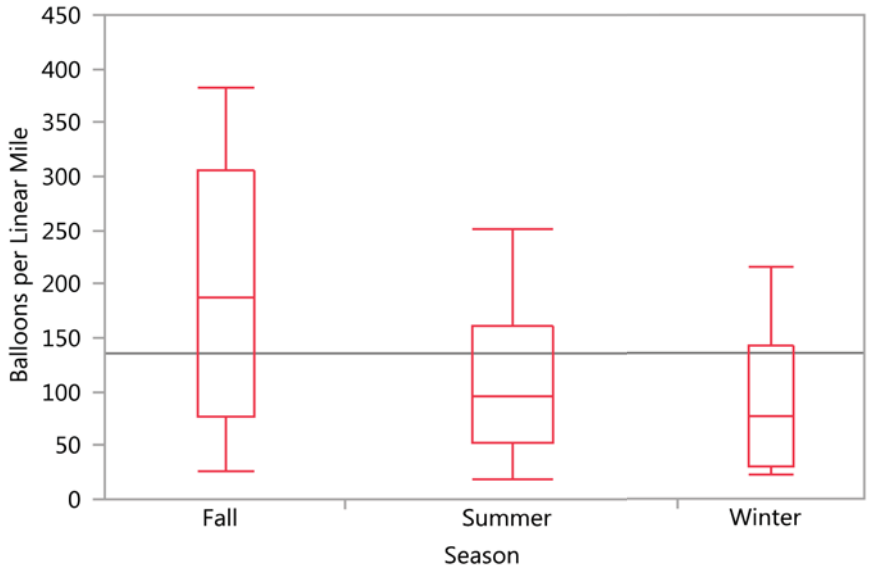
Means and Std Deviations

Level	Number	Mean	Std Dev
Fall	15	344.684	445.517
Summer	18	122.424	96.852
Winter	10	88.819	62.042

Next we run the ANOVA with the two outliers removed ((False Cape, Fall, 1713.33) and (Smith Island, Fall, 988)). From the output below, the p-value is just above the 5% significance level (p=0.0513). While the result is not significant, it is indicating a potential greater number of balloons per linear mile in the Fall than in the Summer and Winter, which are showing no difference in means. More data and more consistent data collection may resolve this.

Appendix G – Statistical Analysis Notes (continued)

Oneway Analysis of Balloons per Linear Mile By Season



Missing Rows 5
Excluded Rows 2

Oneway Anova

Summary of Fit

Rsquare	0.14472
Adj Rsquare	0.099706
Root Mean Square Error	99.27065
Mean of Response	135.6283
Observations (or Sum Wgts)	41

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Season	2	63364.65	31682.3	3.2150	0.0513
Error	38	374477.14	9854.7		
C. Total	40	437841.79			

Means for Oneway Anova

Level	Number	Mean	Std Error	Lower 95%	Upper 95%
Fall	13	189.918	27.533	134.18	245.65
Summer	18	122.424	23.398	75.06	169.79
Winter	10	88.819	31.392	25.27	152.37

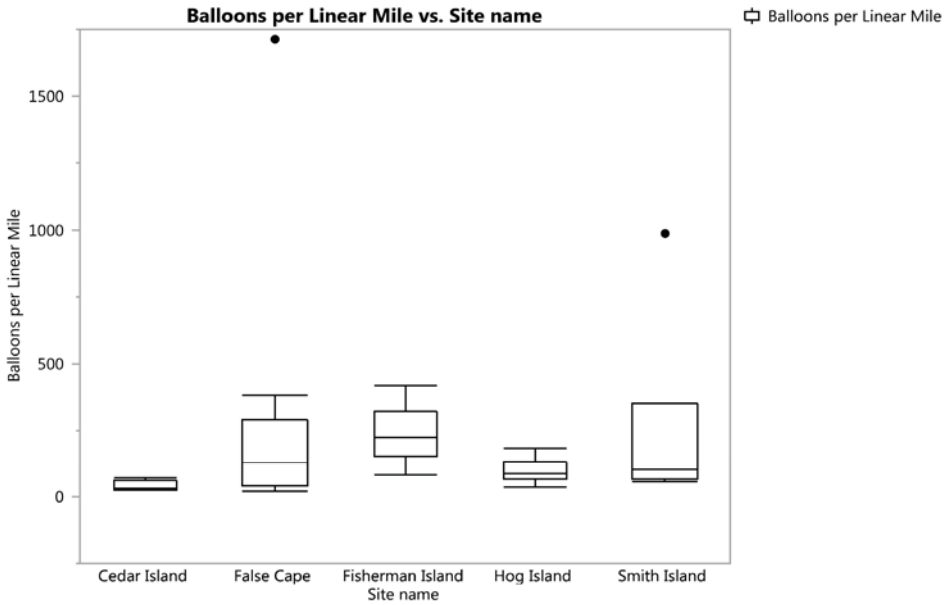
Std Error uses a pooled estimate of error variance

Means and Std Deviations

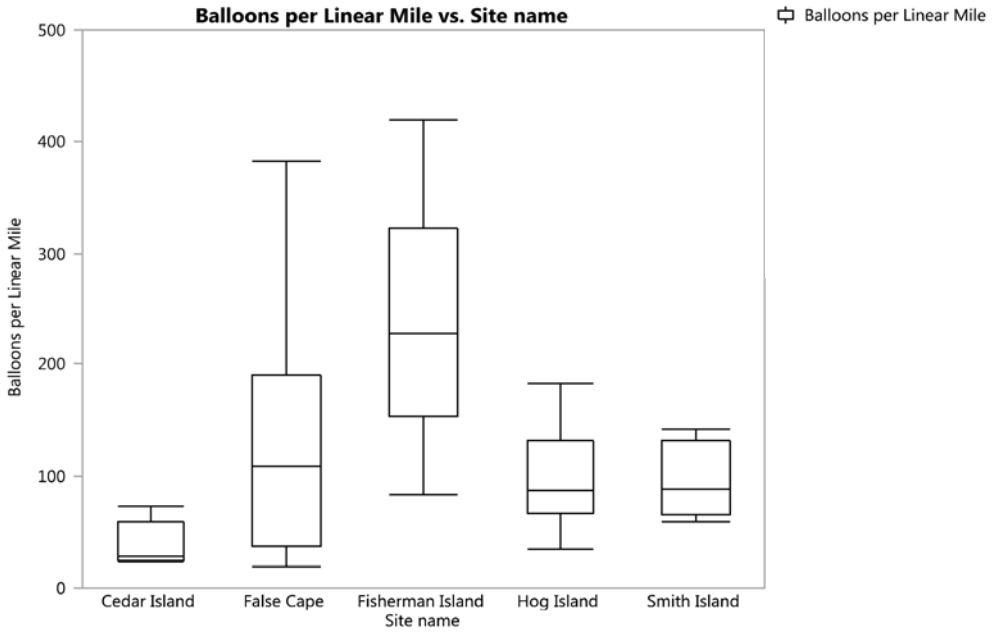
Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Fall	13	189.918	122.600	34.003	115.83	264.00
Summer	18	122.424	96.852	22.828	74.26	170.59
Winter	10	88.819	62.042	19.620	44.44	133.20

Appendix G – Statistical Analysis Notes (continued)

Finally, we run the one-way ANOVA using the Site variable. First, let's observe a box plot of the data below. Again we see the presence of the large outliers. We will again remove those and replot.



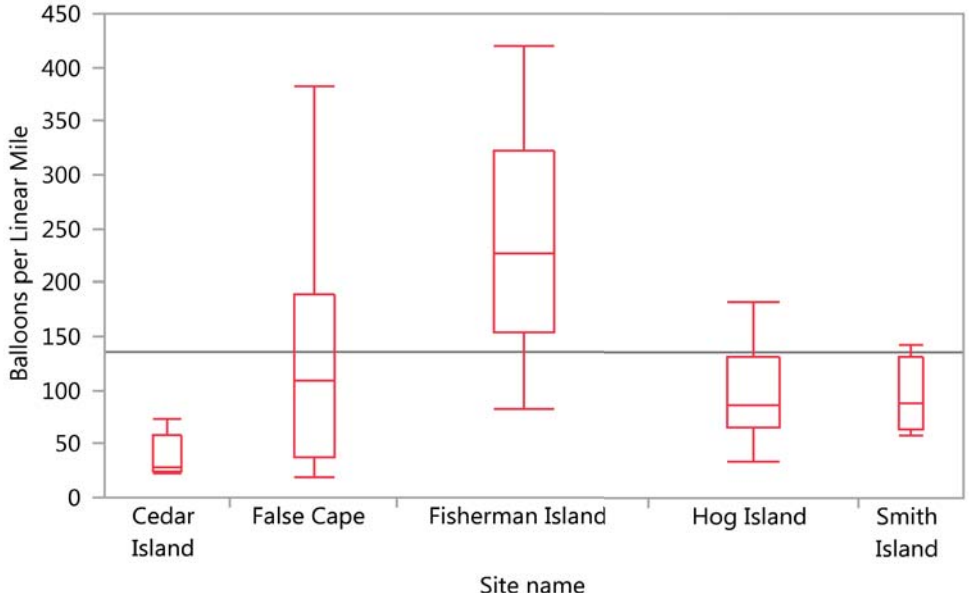
Removing the outliers, we see that Fisherman's Island appears to have more balloons per linear foot than the others. Next we run the ANOVA to compare.



Below is the one-way ANOVA output. First we note a significant result indicating that at least one mean is different. However, we once again do not meet the common standard deviation condition. For the post-hoc analyses we recommend using the more conservative Tukey-Kramer HSD which indicates that the mean number of balloons per linear mile for Fisherman Island and for False Cape are significantly different (larger in this case) than the other locations, which do not have a significant difference. Based on the graphs, we would argue that False Cape is significantly higher due to the right skew of its distribution.

Appendix G – Statistical Analysis Notes (continued)

Oneway Analysis of Balloons per Linear Mile By Site name



Missing Rows 5
Excluded Rows 2

Oneway Anova

Summary of Fit

Rsquare	0.446589
Adj Rsquare	0.385099
Root Mean Square Error	82.04106
Mean of Response	135.6283
Observations (or Sum Wgts)	41

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Site name	4	195535.30	48883.8	7.2628	0.0002*
Error	36	242306.49	6730.7		
C. Total	40	437841.79			

Means and Std Deviations

Level	Number	Mean	Std Dev
Cedar Island	6	38.668	20.253
False Cape	8	133.209	119.106
Fisherman Island	12	234.174	103.456
Hog Island	10	97.378	45.153
Smith Island	5	95.842	34.882

Appendix G – Statistical Analysis Notes (continued)

Post-Hoc Means Comparisons:

Comparisons for each pair using Student's t
Connecting Letters Report

Level				Mean
Fisherman Island	A			234.17417
False Cape		B		133.20875
Hog Island		B	C	97.37800
Smith Island		B	C	95.84200
Cedar Island			C	38.66833

Levels not connected by same letter are significantly different.

Comparisons for all pairs using Tukey-Kramer HSD
Connecting Letters Report

Level			Mean
Fisherman Island	A		234.17417
False Cape	A	B	133.20875
Hog Island		B	97.37800
Smith Island		B	95.84200
Cedar Island		B	38.66833

Levels not connected by same letter are significantly different.

SMITH ISLAND
10-19-16
258
HAPPY BIRTHDAY
HAPPY
Birthday
GRAD