The State of Marine Debris in North Carolina:

An Assessment of Prevention and Removal Efforts

North Carolina Coastal Federation
Working Together for a Healthy Coast

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Sea Grant North Carolina

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This document was produced to inform the development of a strategic marine debris reduction plan for coastal North Carolina. Access to the reduction plan is via the North Carolina Coastal Federation's website (nccoast.org) or by calling 252-393-8185.

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LIST OF ACRONYMS

ADV	Abandoned and Derelict Vessel
DFG	Derelict Fishing Gear
POP	Plastic Ocean Project
NCMMSN	North Carolina Marine Mammal Stranding Network
NCMRP	North Carolina Monofilament Recycling Program
NOAA	National Oceanic and Atmospheric Administration
UNCW	University of North Carolina Wilmington
USACE	United States Army Corps of Engineers

EXECUTIVE SUMMARY

The National Oceanic and Atmospheric Administration (NOAA) defines marine debris as "… any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment." It is a widespread pollution issue of local, national and international significance, impacting human health and welfare, wildlife, habitats and economies. Efforts to assess and address marine debris can help to prevent or offset its impacts and support healthy coastal economies and ecosystems.

In North Carolina, there is not a program, organization or agency that coordinates coast-wide marine debris reduction efforts. In order to strategically address marine debris along North Carolina's coast through the policies and programs of various stakeholders coordinated by the North Carolina Coastal Federation, a process was undertaken in 2017-18 to assess the current status of marine debris in the state as a foundation for the development of a reduction plan. The assessment was developed by a leadership team consisting of representatives from local and state government agencies, nonprofit organizations and academia with input from other marine debris stakeholders.

This assessment describes the problem and management of marine debris in North Carolina, including primary types of concern and associated impacts; gaps and challenges in debris management; and a summary of active stakeholders and their perceptions of and contribution to addressing marine debris. The intention of the assessment is to establish the groundwork for developing a strategy that will be implemented through the coordinated work of coastal marine debris stakeholders.

The process of developing the assessment involved literature and data reviews, an online stakeholder survey, one-on-one interviews, input from attendees of the 2017 North Carolina Marine Debris symposium, input from attendees of the 2018 *Debris-free North Carolina* stakeholder workshop, review of marine debris assessment and reduction plans from other states and many facilitated meetings of the leadership team. The assessment focused on the four most prevalent broad categories of debris that emerged from the process: consumer debris, abandoned and derelict fishing gear, abandoned and derelict vessels and storm generated debris.

Consumer debris is the most common type of debris found in North Carolina and its impacts have been documented to include wildlife entanglement, wildlife ingestion and habitat damage. It is challenging to prevent consumer debris, as a number of factors contribute to it and sources are often difficult to identify.

Derelict or abandoned fishing gear is a concern because it can continue to capture and kill or injure wildlife and pose navigational hazards. Sources of fishing gear are relatively easy to identify. Marked progress is currently being made by the state and a nonprofit partner to hire commercial fisherman to locate and remove lost or abandoned gear to protect habitat, the state's commercial fisheries and safe navigation.

Abandoned and derelict vessels are a type of marine debris estimated to be in at least the hundreds along the North Carolina coast. Hurricane Florence (September 2018), caused almost 400 vessels to become displaced, elevating the problem of these vessels to a higher level of concern amongst the public and lawmakers. A formal abandoned and derelict vessel program, statewide law, or dedicated funding source does not exist at the state level. However, local governments can pass their own ordinances to address these vessels, but the majority of local governments in the coastal counties have not established such laws. Derelict or abandoned vessels can cause environmental damage, navigation hazards and are unsightly.

Storm debris is caused by destruction of buildings, docks, bulkheads, public infrastructure or scattering of existing debris. Storm debris can alter habitat, harm wildlife and endanger public health. In addition to documented impacts to wildlife, habitat, human health and navigation, stakeholders engaged in the assessment indicated that aesthetic, recreational and economic impacts were also important.

The assessment team characterized debris found in North Carolina by analyzing debris cleanup data generated from 1986 to 2016 by the Ocean Conservancy's International Coastal Cleanup and the Marine Debris Tracker App. It was found that 400,000 volunteers assisted in collecting 12 million pounds, or about 5 million pieces, of primarily consumer debris. The most frequent items removed were cigarette butts and the most common material type was plastic. North Carolina debris data was found to be very similar to both national and international data.

Marine debris stakeholder affiliations, experiences, perceptions and debris-related activities were identified using an online survey that was completed by 111 respondents. Affiliations of respondents included mostly state government, nonprofit and volunteer, and local government followed by academia, business and industry, and federal government. Respondents considered wildlife, aesthetic and human health impacts of marine debris as the top concerns. Most respondents focused their marine debris related activities on education, outreach, and removal of consumer debris, the most common type of debris identified through cleanup activities in North Carolina. When asked about the most effective strategies to address marine debris, respondents identified the following as most important: education and outreach, laws and enforcement, and waste management and reduction. Finally, stakeholders were asked if they would be willing to participate in and/or implement a coast-wide marine debris reduction plan, which generated mostly positive responses.

Several marine debris research, prevention and reduction initiatives, including externally funded projects, were identified through the assessment process and are listed or described in this document. These efforts include voluntary compliance programs, impacts and characterization research, use of technology to identify marine debris and removal programs.

This assessment revealed many challenges and opportunities related to the management of marine debris in North Carolina, many of which could be addressed through the coordinated work of marine debris stakeholders in North Carolina. The development of a Marine Debris Reduction Plan for the state will provide a framework for this coordinated work to occur.

INTRODUCTION

Marine Debris in North Carolina

North Carolina is home to a biologically rich coast and the second-largest estuarine system in the United States, the Albemarle-Pamlico Estuary. There are 325 miles of beach shoreline, 12,000 miles of estuarine shoreline and 2.2 million acres of estuarine waters in North Carolina, all supporting unique and biodiverse coastal and marine ecosystems (McVerry, 2012; North Carolina Coastal Atlas, 2018).

The tourism and fishing industries in North Carolina depend on the health of these ecosystems, as they provide important ecosystem services to communities throughout the state, including protection from storms, recreation, improved water quality, nursery habitat for important fish and shellfish species and biodiverse marine ecosystems (Barbier, et al., 2011). The coast of North Carolina is especially biodiverse due to its unique geography as the continental slope sits roughly 40 miles offshore Cape Hatteras, making North Carolina the closest landmass to the continental slope on the east coast. The Gulf Stream and Labrador currents meet in this area, creating a productive marine ecosystem that is home to many marine mammals, endangered species and commercially- and recreationally-important fish species (National Park Service, 2015). North Carolina's people, wildlife and habitats are affected by marine debris and increased coastal development in the state is exacerbating this critical issue.

For purposes of this document, the NOAA marine debris definition is used:

> "…any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment."

Concerns with Marine Debris

Marine debris can negatively influence coastal environments in a variety of ways, including but not limited to: habitat damage, wildlife entanglement and ingestion, ghost fishing, vessel damage, navigational hazards, aesthetic decline and invasive species transport. Human health can also be influenced. Direct impacts to humans may occur when hazardous materials are deposited on beaches or coastal waters. Humans can also be influenced indirectly, when debris, particularly microplastics, are transported through the food chain (Miranda & Carvalho-Souza, 2016).

Marine debris is continually entering our state, national and global waters and the federal Marine Debris Research, Prevention, and Reduction Act (amended 2012) recognized the need for a program to address the sources and impacts in United States (U.S.) waters. However, quantifying marine debris impacts is a difficult task and few studies have been completed in North Carolina to make specific determinations.

Summary of Marine Debris Types

For the purposes of this assessment, marine debris is broadly categorized as consumer debris, abandoned and derelict fishing gear, abandoned and derelict vessels, and storm debris. These debris types are generally managed through prevention and/or removal activities.

Development and Goals of Assessment

In 2017, a small group of concerned governmental and nonprofit collaborators, including the North Carolina Coastal Federation, North Carolina Coastal Reserve, North Carolina Sea Grant, Onslow County Solid Waste Department and the North Carolina Marine Debris Symposium began to characterize and assess the extent of this type of pollution, including current management efforts directed at preventing and cleaning up debris and the extent of stakeholder involvement in addressing the problem.

The North Carolina Coastal Federation initially convened the group based on their mission-oriented interest in understanding marine debris pollution in North Carolina and how it could be better addressed through a debris reduction strategy. To inform the development of a reduction strategy through a collaborative stakeholder process, the team first conducted an assessment of what is currently being done to address marine debris along the coast.

The information in this assessment focuses primarily on the 20 coastal counties as defined by the North Carolina Division of Coastal Management's Coastal Area Management Act. The purpose of this work is to reveal challenges, gaps and opportunities in marine debris management within the state with the goal of developing a coast-wide marine debris reduction framework.

More specifically, the goals of this assessment project include the following:

- Understand the types and quantities of marine debris found in the North Carolina coastal environment.
- Understand the threats and potential impacts of different types of marine debris.
- Identify organizations that are involved with marine debris research, removal, and prevention.
- Identify current initiatives aimed at reducing and/or preventing debris.

This document is based on information collected from various publications, interviews with stakeholders, an online stakeholder survey and International Coastal Cleanup and Marine Debris Tracker App data. Currently, no agency in the state handles coast-wide coordination of marine debris prevention, reduction and management efforts making it difficult to efficiently perform a full assessment of these activities. This document is a first-time effort to comprehensively characterize the status of marine debris and its management in North Carolina

This assessment is a living document and is subject to change as additional information becomes available. It will be used to inform development of marine debris reduction actions and will be initially maintained by the North Carolina Coastal Federation in coordination with state agencies and local stakeholders.

Debris Removal Data

Data collected during debris removal efforts was used to help characterize marine debris pollution in North Carolina. Information on the types and amounts of debris was acquired from the Ocean Conservancy's International Coastal Cleanup (OCICC) from 1986 to 2016 and the Marine Debris Tracker from 2011 to 2017. Data from these sources was primarily collected by community volunteers and is presented throughout this document where relevant to the topic. The OCICC figures include information from coastal and inland debris removal events and the inland data was not extracted from the set.

Online Survey

To more fully understand what is being done to address marine debris management by various stakeholders in the state, the assessment team administered an online survey. The survey was intended to collect information about marine debris stakeholder experiences, perceptions and activities and to identify their willingness to participate in developing a coast-wide marine debris reduction strategy. A secondary purpose was to collect contact information that would enhance an existing database of stakeholders.

The survey link was distributed via email to known and potential marine debris stakeholders and was posted on social media sites of the assessment team organizations and partners. The survey was open for 23 days and there were 111 valid responses included in the analysis. Respondents included business and industry, government, nonprofit and academic organizations.

Selected survey data is presented throughout this document in relevant sections. A summary of survey results can be found in Appendix D.

SCOPE OF PROBLEM AND MAJOR CONCERNS

Understanding the Extent of the Problem

Studies show the main economic sectors which contribute to marine debris include retailers, agriculture, shellfish mariculture, fisheries, commercial shipping, recreational boating, coastal municipalities (e.g debris removal), coastal tourism and emergency rescue services (Newman, Watkins, Farmer, Brink, & Schweitzer, 2015).

Marine debris data is almost exclusively gathered during debris removal activities in North Carolina, but it is important to note that data is not gathered during all debris removal events. Marine debris removal activities are conducted throughout the year in the state; however, many of the activities are executed during the period of the Ocean Conservancy's International Coastal Cleanup (OCICC) held each fall.

Figures 1-3 highlight data from volunteer cleanups in North Carolina from 1986 to 2016 and provide some understanding of the quantities and types of debris found in coastal North Carolina. Due to logistical, human safety and resource limitations, cleanup activities in North Carolina primarily focus on removal of typical shoreline debris primarily comprised of consumables such as cups, plates, bottles and cigarette butts. Therefore, this data may not provide a complete picture of the debris composition that is found along coastal North Carolina.

The data may under represent habitat-damaging items such as large pieces of lumber, appliances, or vehicles and vessels that may be difficult to remove. It is also important to note that not all cleanups during this time frame recorded data.

The below figures are based on data from the University of Georgia's Marine Debris Tracker App and Ocean Conservancy International Coastal Cleanup database. Results show the number of volunteers, pounds and pieces of debris removed over thirty years. It also highlights the top 10 items collected, and a breakdown of debris composition into broad categories based on material type. The majority of debris was found to be plastic, which is consistent with national and international clean-up data.

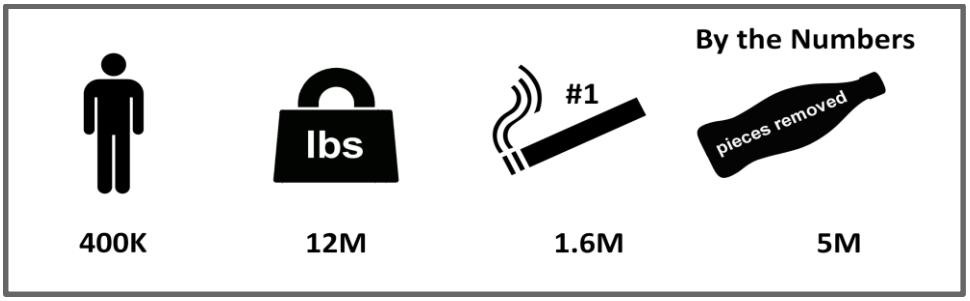

Figure 1. *From 1986 to 2016, 400,000 volunteers assisted in collecting 12 million pounds of primarily consumer debris in North Carolina Five million pieces of debris were removed, including the top item - 1.6 million cigarette butts. Data provided by the Ocean Conservancy International Coastal Cleanup.*

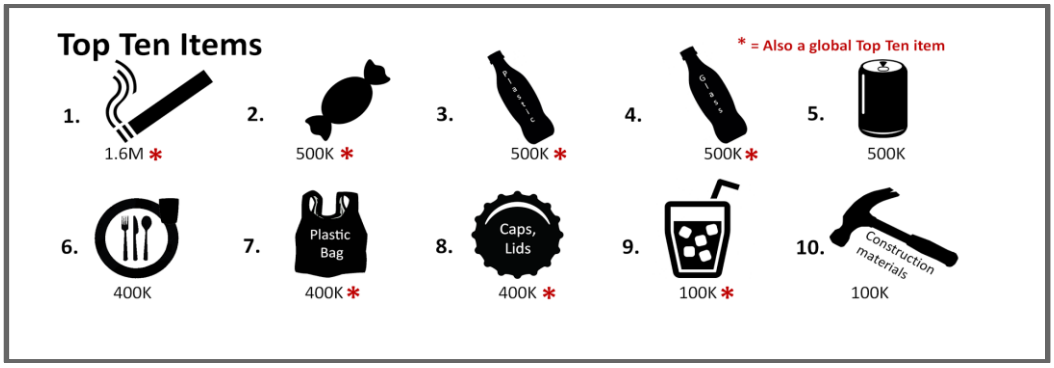

Figure 2. *Top ten items found in North Carolina during Ocean Conservancy International Coastal cleanups from 1986 to 2016. With the exception of construction materials, the most frequent type of debris removed is consumer debris.*

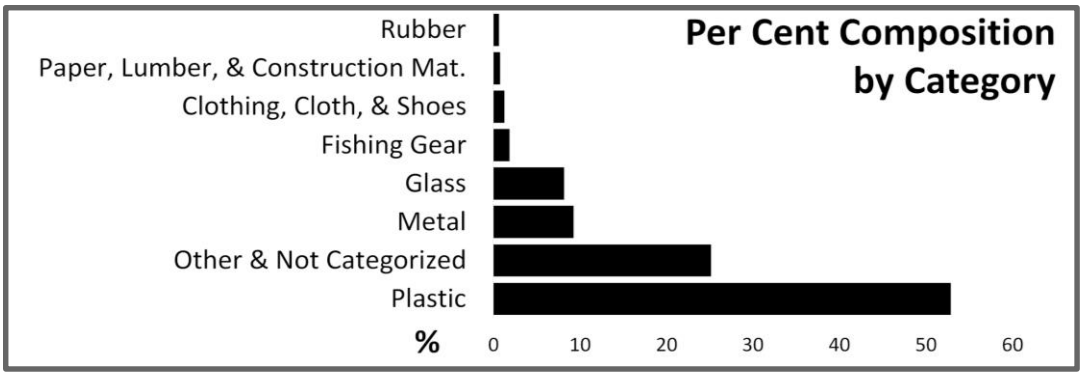

Figure 3. *Percent composition by category of marine debris collected in North Carolina from 1986 to 2017. Plastic contributes more than any other category, which is consistent with international cleanup data. Data is from the University of Georgia's Marine Debris Tracker and Ocean Conservancy International Coastal Cleanup.*

Figure 4. *Estimated decomposition rates of common marine debris items.* (ECOVENTURES INFOGRAPHICS)

Impacts of Marine Debris

In the 2017 online survey administered to marine debris stakeholders, respondents were asked "Based on your professional experience related to marine debris, what are the impacts of marine debris found in coastal North Carolina?" Responses are summarized in Figure 5. The two highest ranking perceived impacts include wildlife entanglement and/or ingestion and aesthetic and recreational impacts.

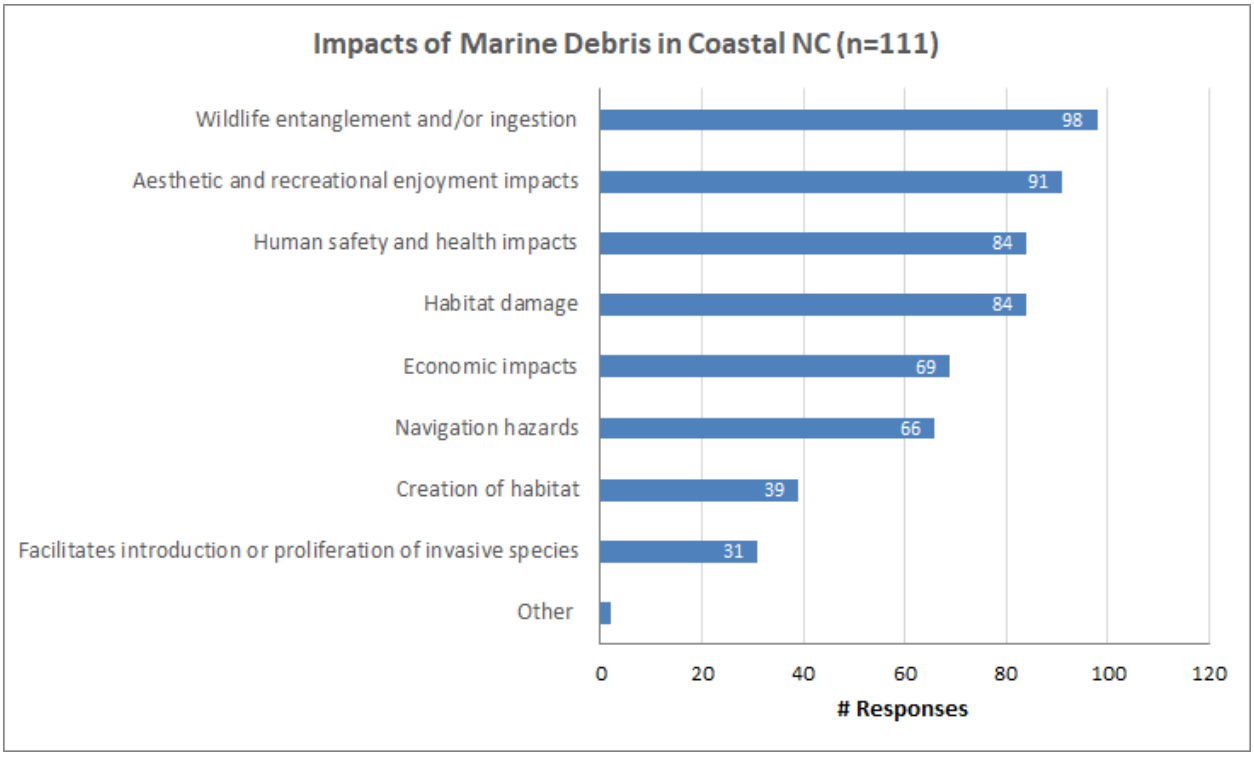

Figure 5. *Survey results show perceived marine debris impacts in coastal North Carolina Respondents were asked "Based on your professional experience related to marine debris, what are the impacts of marine debris found in coastal North Carolina?" The impacts were listed (vertical, y-axis) and respondents could choose all that applied.*

Entanglement

A 2014 NOAA Marine Debris Report identified that in the U.S., at least 115 different marine species have become entangled in plastic marine debris (NOAA, 2014a). This number includes fish, sea turtles, seabirds, cetaceans, shellfish and other invertebrates commonly found in North Carolina waters.

Entangled organisms can experience a variety of effects, depending on the type of debris encountered. Entanglements may result in injured or lost appendages that interfere with the organism's ability to feed, swim and reproduce. Should an animal free itself from entanglement, they may still suffer from sublethal effects that shorten their lifespan (NOAA, 2014a).

It is difficult to fully understand the extent and impact of wildlife entanglement caused by marine debris in North Carolina as data is limited. Entanglement data is usually collected incidental to natural resource monitoring or stewardship efforts such as during bird and turtle surveys, debris cleanups, or when a citizen opportunistically encounters and reports an entangled animal to the appropriate response agency.

In 2015, researchers and collaborators associated with the North Carolina Marine Mammal Stranding Network, sought to rescue a juvenile dolphin that had become increasingly injured by an Aerobie rigid plastic flying ring that had slipped over its head (Figure 6a). A rescue team was assembled and searched for three days in Roanoke Sound, North Carolina but the injured dolphin was never found to execute the removal of the ring. No carcass was found; but, the dolphin's mother was seen without him, which led the team to believe that the entangled dolphin likely did not survive.

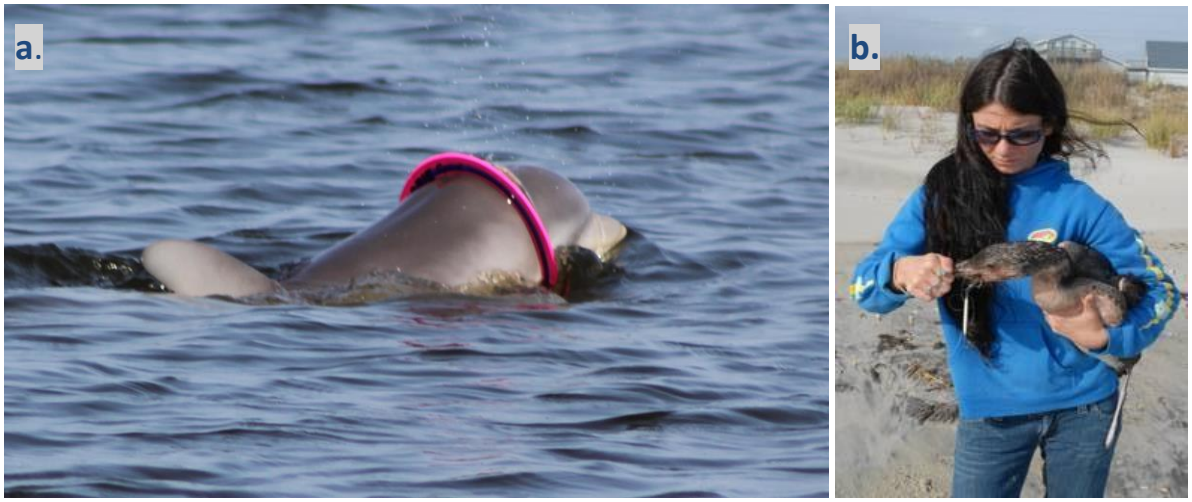

Figure 6. *a) Atlantic bottlenose dolphin with injuries from a rigid plastic flying ring that had slipped over its head (photo courtesy of North Carolina Marine Mammal Stranding Network, photographer unknown); b) Disentangling a Common Loon from plastic fishing line near a pier in Topsail Beach (photo by Dr. Gilbert S. Grant).*

Additional information on entanglement can be found in the abandoned and derelict fishing gear section on page 22.

Ingestion

Marine animals are known to ingest consumer debris such as plastic bags, balloons and other marine debris when they mistake it for a food source or accidentally ingest it during normal feeding (NOAA, 2014b).

Debris can also be consumed by organisms indirectly if their prey has eaten debris (NOAA, 2014b). Ingested debris can cause throat or digestive tract obstruction and damage to the gut (Figure 7a, dental pick), resulting in malnutrition or death. According to NOAA, physiological effects from ingestion also include nutritional, developmental, immunological and toxicological concerns (NOAA, 2014b).

Data about ingested debris is typically documented through research studies, necropsies of deceased animals, during rehabilitation of sick or injured animals and incidentally during some natural resource surveys. For example, marine mammal and sea turtle necropsies are often performed on stranded animals that are processed through the North Carolina Marine Mammal Stranding Network (NCMMSN) and the North Carolina Sea Turtle Stranding Network, respectively. According to the NCMMSN (V. Thayer, personal communication, January 17, 2018), 3 percent (4 of 116) of marine mammal stomachs examined during necropsies between 2009 and 2017 presented with or contained macroplastic debris (Figure 7d).

Due to the difficult nature of detecting microplastics, small pieces could have been missed when examining digestive tracts. From 2014 to 2015, there were five leatherback sea turtle mortalities in North Carolina and four of those five had ingested plastic. In one case, a wad of plastic was found in the lower chamber of the stomach, which could have interfered with gastric emptying (Figure 7b). In the other three cases, the plastic likely did not contribute significantly to the turtles' demise, but it could have caused sublethal effects (C. Harms, personal communication, January 16, 2018).

Ingested debris can also be detected in some animals while they are being rehabilitated. In January 2018 volunteers at the Karen Beasley Sea Turtle Rescue & Rehabilitation Center discovered shards of hard plastic mixed in with the feces of a loggerhead sea turtle that was receiving care at the facility (Figure 7c).

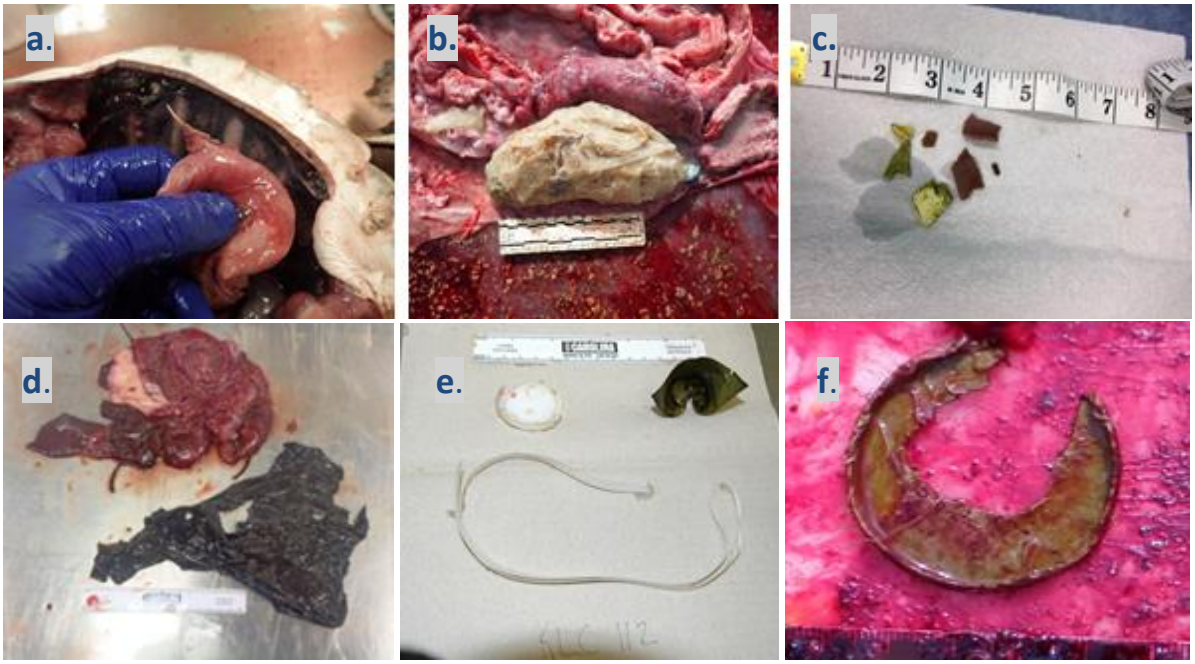

Figure 7. *a) A plastic dental pick perforated the pyloris of a green sea turtle that stranded in North Carolina (photo by Dr. Craig Harms, North Carolina State University); b) A wad of plastic found in the stomach of a leatherback sea turtle that stranded in North Carolina (photo by Emily Christiansen, North Carolina State University); c) Plastic shards found in the feces of a loggerhead sea turtle that was receiving rehabilitation services at the Karen Beasley Sea Turtle Rescue & Rehabilitation Center (photo contributed by Jean Beasley); d) A plastic fragment found in the forestomach of a pygmy sperm whale calf (photo contributed by J. Sullivan); e) Three pieces of plastic found in the stomachs of a True's beaked whale that stranded in North Carolina (photo contributed by UNCW); f) A plastic cap fragment found in the stomach of a Gervais' beaked whale that stranded in North Carolina (photo contributed by Cape Hatteras National Seashore).*

Microplastics have been confirmed in smaller invertebrates including zooplankton, mollusks, and crustaceans, which make up the bottom of the food chain (NOAA, 2014b). Research currently being conducted at the Duke University Marine Laboratory in Beaufort, North Carolina shows that these foundational species, such as corals and anemones, eat plastic because they perceive it as food by taste (Allen, Seymour, & Rittschof, 2017). Flavors are likely due to some of the 50 to 150-plus different molecules that leach out of brand new commercial plastics commonly sold in the retail market. This research has revealed that anemones feed on more acutely toxic plastic longer than they do less acutely toxic plastics. Studies are underway to see if heavy metals used in processing plastics are removed by anemones. (D. Rittschof, personal communication, January 10, 2018)

Aesthetic, economic and recreational impacts

Visitors and citizens value a clean coast and the presence of debris in waterways and on beaches can impact aesthetics and overall enjoyment of North Carolina coastal resources. The World Health Organization defines the effects of aesthetic issues on the amenity value of coastal systems as: loss of tourism; damage to leisure/tourism infrastructure; damage to commercial activities dependent on tourism; damage to fishery activities and fishery-dependent activities; and damage to the local, national and international image of a resort (Philipp, 1993). A study led by the NOAA Marine Debris Program in Orange County, California, found that reducing marine debris at beaches by even 25 percent could benefit residents by roughly $32 million from increased summer tourism and recreation (NOAA, 2017). These impacts have not been measured in North Carolina, but it can be reasonably assumed that they exist.

MARINE DEBRIS TYPES: BACKGROUND, CONCERNS AND INITIATIVES

Consumer Debris

Consumer debris is primarily man-made product packaging materials. In North Carolina, these materials are associated with intentional and unintentional littering and are commonly found on roadsides. Consumer debris can come from someone tossing it out the window, materials blowing out of a recycle bin on a windy day, people not picking up after themselves or from uncovered loads heading to a landfill.

These materials enter the marine environment by way of stormwater outfalls, creeks, rivers and bridges. Boating and fishing, as well as beach recreation, can also lead to intentional or unintentional consumer debris input into the marine environment.

***Figure 8**. Beachgoer debris at Indian Beach, North Carolina in July 2016 (photo by Lisa Rider).*

Consumer debris is, in part, attributed to the lack of access to proper solid waste infrastructure. Consumer debris includes, but is not limited to: beverage containers, plastic bags and bottles, foam coolers, drinking straws, balloons and cigarette butts. Plastics are of particular concern, due to their abundance, persistence in the environment and tendency to break into smaller pieces which can easily enter the food chain (Jambeck, et al., 2015).

Plastics can also enter waterways in small particles known as microplastics. These plastics include pre-production plastic pellets, microbeads and microfibers or any pieces less than 5 mm in diameter (Andrady, 2011). Pre-production pellets are used as feedstock for the production of plastic products and are often released into the environment. Additionally, microbeads used in cosmetics and microfibers from polyester clothing enter the ocean as current technology does not filter them from wastewater.

Hundreds of thousands of fibers can be released by a single load of laundry (Hartline, et al., 2016). Microplastics have shown to be ingested by organisms at the bottom of the food web, like plankton (Cole, et al., 2013). In addition to the toxins already within microplastics, they absorb harmful chemicals onto their surface due to their physical chemistry (Safina & Perelman, 2016). Once microplastics enter the food web, the plastic particles are passed from one species to another and their associated toxins biomagnify, becoming even more toxic (Putnam, Hammer, VanBrocklin, Buksa, & Clune, 2017).

The North Carolina Coastal Federation also has an assessment on microplastics, which details the consequences of microplastics as well as current solutions. Existing solutions include using sink and laundry filters or washing machine additives to remove microplastics from water sources at the consumer level. At the city level, one way to combat the amount of microplastics entering the waterways would be to upgrade the current wastewater treatment plants.

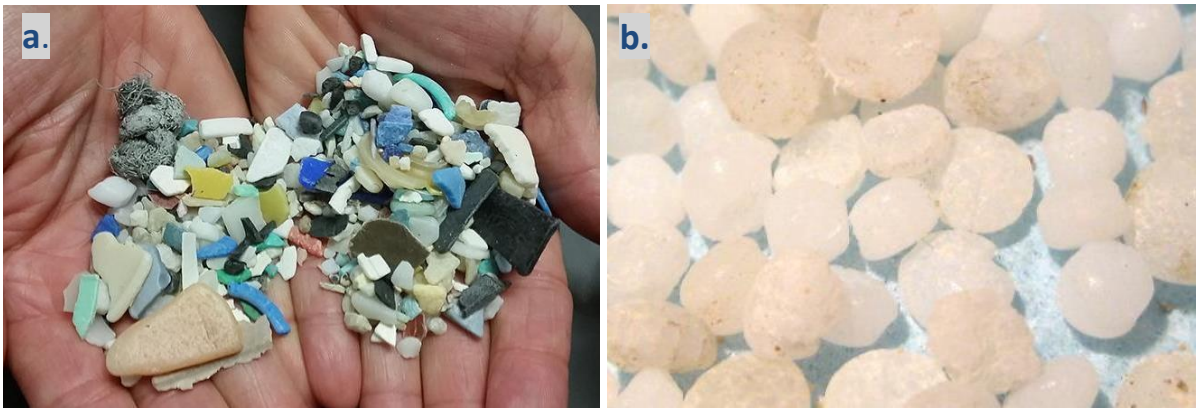

***Figure 9**. a) Microplastics created from the breakdown of larger pieces of plastic debris; b) Plastic preproduction pellets used to manufacture plastic (photos by NOAA).*

Documented threats from consumer debris include wildlife entanglement and ingestion, aesthetic impacts and habitat damage. Human consumption of contaminated fish or shellfish also pose public health concerns (Miranda & Carvalho-Souza, 2016). Accumulation of debris on the surface of marine environments can also reduce the amount of light which penetrates to deeper waters, altering subsurface habitats (U.S. Environmental Protection Agency, 2011).

Current and past initiatives and policies

Policies have been adopted to address some sources of consumer debris in North Carolina. It is illegal under North Carolina law to haul an improperly secured load. Penalties for littering include up to a $2,000 fine, community service work and one point on a motorist's driver license upon conviction. When litter is blown, scattered, spilled, thrown or placed from a vehicle or watercraft, the operator thereof shall be presumed to have committed this offense. (Section 1. G.S. 14-349)

The North Carolina Department of Transportation and the Administrative Office of the Courts (AOC) tracks the number of tickets issued each year, including littering citations. Research shows that public awareness programs which seek to change behavior must have a strong law enforcement component.

The following data is from the AOC's Court Information System. The numbers include charges by the following agencies: Alcoholic Beverage Commission, Alcoholic Law Enforcement, North Carolina Police, Division of Motor Vehicles, North Carolina Sheriff, State Highway Patrol and Wildlife Resources Commission.

Table 1. *Number of charges, convictions, and percentage of littering violations per year as administered by the Alcoholic Beverage Commission, Alcoholic Law Enforcement, North Carolina Police, Division of Motor Vehicles, North Carolina Sheriff, State Highway Patrol and Wildlife Resources Commission.*

Year	Charges	Conviction	Percentage
2001	4059	2219	55 percent
2002	3601	1951	54 percent
2003	3266	1804	55 percent
2004	3469	2005	56 percent
2005	3732	1986	53 percent
2006	4035	1948	48 percent
2007	4177	2043	49 percent
2008	3901	1939	50 percent
2009	3433	1558	45 percent
2010	3485	1531	44 percent
2011	3293	1455	44 percent
2012	3163	1663	53 percent
2013	2855	1030	36 percent
2014	2826	984	35 percent
2015	3506	1373	39 percent
2016	3479	1262	36 percent

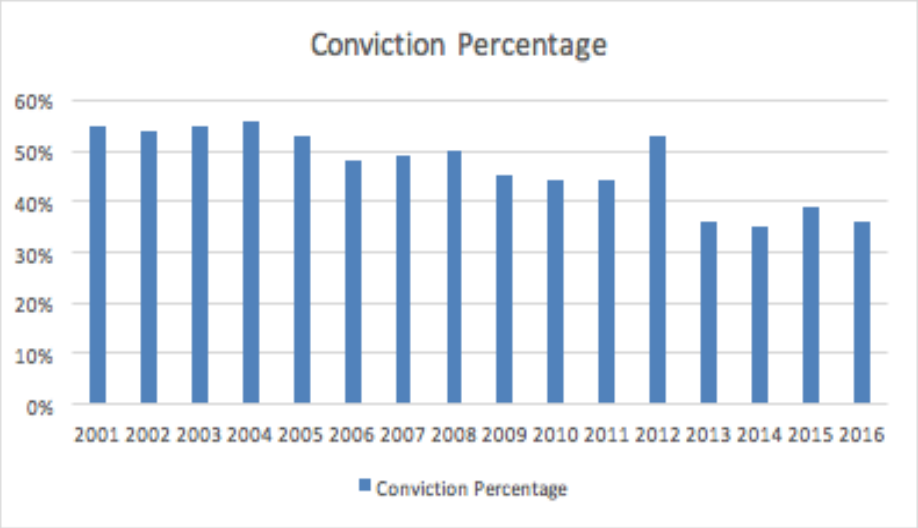

Figure 10. *Percentage of littering convictions per year as administered by the Alcoholic Beverage Commission, Alcoholic Law Enforcement, North Carolina Police, Division of Motor Vehicles, North Carolina Sheriff, State Highway Patrol and Wildlife Resources Commission.*

North Carolina Department of Transportation expects to spend $19 million this year paying its employees and contractors to pick up trash, transitioning from contracting with the Department of Correction for prisoners to do the cleanup work. Cleanup contractors will make multiple passes along nearly all of the 1,340 miles of interstate highway in North Carolina this year and a little more than 60 percent of the nearly 13,800 miles of primary roads. But due to a lack of funding, fewer than 10 percent of the 65,000 miles of secondary roads in the state are covered by the trash cleanup contracts. (Stradling, 2018a, 2018b)

One way consumer debris is being addressed is by means of solid waste infrastructure and coastal area cleanups. Proper solid waste disposal access has been shown to be very important in preventing marine debris (Jambeck, et. al, 2015). Proper disposal access also includes timely waste collection bin servicing to insure collection bins are not overflowing.

Twinning the bin (recycle bins next to trash bins) provides easy access and helps keep recycle market contamination down. Some coastal communities are also incorporating bin systems for cigarette butts and cleanup stations, in their waterway access locations. For example, Blue Tubes are small containers made from recycled materials, installed at public beach entrances and are filled with clean plastic bags for visitors to use to pick up and throw away trash on the beach (Blue Tube Beach). Volunteers are encouraged to donate bags to keep the receptacles full and sponsors are often sought to offset costs of supplies and installation.

***Figure 11**. Blue Tube placed at Onslow County Public Beach Access in North Topsail Beach 2017 (photo by Lisa Rider).*

In an attempt to address the issue of plastic pollution, the North Carolina General Assembly passed a bill in 2009 banning the use of plastic bags on the Outer Banks. The ban detailed that retailers had to replace disposable plastic bags with paper bags and offer some form of an incentive for every reusable bag used by a customer. There were some exceptions made such as durable plastic bags that had handles, were designed for reuse and were at least 2.25 mm thick were allowed as well as stores that were less than 5,000 square feet and had less than five stores in the state did not have to follow the ban (Crist, 2017).

However, the bill was repealed in 2017 as a provision of the North Carolina General Assembly Session Law 2017-209, House Bill 56, and merchants are able to resume the use of plastic bags. Understanding the need to reduce single-use plastics, many businesses continue to abide by the requirements of the ban despite its repeal.

Businesses that commit to reducing single-use plastics are able to participate in a program known as Ocean Friendly Establishments. The Ocean Friendly Establishments certification program was developed in Wilmington, North Carolina, by nonprofit organizations, Plastic Ocean Project and the Cape Fear Surfrider Foundation Chapter, to reduce single-use plastics in restaurants.

Since its inception, the initiative has been expanding along the North Carolina coast. The primary target of this program has historically been the use of straws in restaurants, but the program has expanded to address plastic bags. This program acts as an incentive for area businesses to reduce single-use plastic by earning recognition on social media. Additionally, the businesses receive a framed certificate to display their contributions to protecting our coastal environment. There are now about 100 Ocean Friendly Establishments in North Carolina. The Town of Duck has recently enacted a resolution in support of this program, urging businesses to become certified. Efforts are underway to recruit other municipalities on the coast to adopt similar resolutions.

c.

Additional Examples of N.C. Stewardship and Education Programs that Address Consumer Debris	
N.C. Youth Ocean Conservation Summit	Student conservation projects focused on marine debris
Wrap Recycling Action Program	Opportunities for consumers to recycle plastic bags and other flexible packaging
Adopt A Beach Programs	Debris removal, Example: Kitty Hawk, N.C.
In Our Hands, N.C. Aquariums	Encourages use of alternatives to single-use plastics
N.C. Stream Watch	Supports rural community groups in removing debris
N.C. Green Travel	Recognition to businesses that prevent waste and debris

Figure 12. *a) Ginger Taylor of Wrightsville Beach Keep It Clean presenting Blockade Runner Beach Resort with their Ocean Friendly Establishment certificate; b) Cavalier Surf Shop's certificate (photos by Plastic Ocean Project); c) Additional consumer debris stewardship and education programs that are not found elsewhere in this document.*

There is no longer a statewide effort for marine debris cleanups, as the formerly statewide Big Sweep program has dissolved into smaller programs in several coastal counties. These groups do not coordinate with each other since they lack an umbrella organization to coordinate their efforts coast wide. This signifies a major gap in addressing the issue of consumer debris, as well as other types of marine debris that are picked up during beach cleanups. There is a strong need for statewide coordination, which could include a consistent method for data collection that can be used collectively to assess the extent of the issue and how it changes with the implementation of reduction efforts.

Education and outreach about consumer debris is a common way that North Carolina marine debris stakeholders contribute to its management. These efforts are carried out at various scales, using very few resources such as social media to executing entire programs dedicated to marine debris education at the local level.

For example, Duke University Marine Laboratory administers a year-long interdisciplinary community science program for select fourth grade classes in Carteret County. The program provides knowledge on marine debris, art mosaic methods, solid waste and recycling, remote sensing via drones and scientific sampling. Armed with this background knowledge, students

then go out into the field to collect data on marine debris accumulation and conduct a beach cleanup at the Rachel Carson Reserve in Beaufort.

Students then use their data to understand local and global marine debris trends and make a difference in their community. Education and outreach is also conducted utilizing established activities and curricula offered through the NOAA Marine Debris Program. Additionally, North Carolina marine debris stakeholder involvement in various marine debris related activities, including education and outreach, is found in Appendix B.

A summary of additional examples of stewardship and education programs addressing consumer debris is found in Figure 12-c, above.

Derelict Fishing Gear

The NOAA marine debris program defines derelict fishing gear as the following:

> "Derelict fishing gear (DFG) refers to nets, lines, crab/shrimp pots, and other recreational or commercial fishing equipment that has been lost, abandoned, or discarded in the marine environment. Modern gear is generally made of synthetic materials and metal, and lost gear can persist for a very long time." (NOAA, 2013)

DFG includes crab pots, equipment for shellfish mariculture and monofilament nets and lines that have been lost, abandoned or discarded. A primary concern with DFG is that it can continue to capture and injure and/or kill both target and non-target species, pose navigational hazards and impact aesthetics. Large heavy pieces of DFG can alter salt marsh vegetation and sediment, making the habitat more vulnerable to the growth of invasive species (Viehman, Pluym, & Schellinger, 2011).

Information on the abundance and distribution of derelict fishing gear is primarily gathered from the North Carolina Division of Marine Fisheries annual statewide crab pot removal program. North Carolina Marine Patrol began recording numbers of lost crab pots collected in 2003.

Since 2014, the North Carolina Coastal Federation has led the Lost Fishing Gear Recovery Project in an effort to remove lost crab pots from North Carolina sounds, with funding assistance from the National Oceanic and Atmospheric Administration, the North Carolina General Assembly and North Carolina Sea Grant. (Lost Fishing Gear Recovery Project). The impacts of DFG on the fisheries economy and living resources are not well understood. There is also incomplete information about the distribution and abundance of other types of DFG not described below. Both recreational and commercial fishing are important to the economy and culture of North Carolina. These industries are expected to continue well into the future. Thus, working with fishers and fishing communities to develop best management practices may be one way to reduce lost, abandoned and derelict fishing gear.

Crab Pots

In North Carolina, it is estimated more than a million crab pots are used in the commercial industry (NCDMF, 2011). An unknown number of pots are deployed by individuals from their docks, shores or nearby waters. It is estimated that 17 percent of crab pots are lost annually (NCDMF, 2008). The blue crab (Callinectes sapidus) fishery of North Carolina is one of the most profitable commercial fishing industries in the State, in terms of landings, value, amount of harvest gear and participants. (North Carolina DENR). Crab pot recovery projects have found both live and dead bycatch such as finfish and diamondback terrapins in 41-45 percent of the retrieved traps (Voss, Browder, Wood, & Michaelis, 2015; Bayliss, 2014).

Crab pots can entangle protected species such as loggerhead sea turtles (see figure 17B below) that try to access catch and/or bait located inside of the pot (Avissar, 2009), though there was no evidence of sea turtles or diamondback terrapins in any retrieved pots during the North Carolina Coastal Federation's Lost Fishing Gear Recovery project (Bayliss, 2017). A crab pot can continue trapping species until the openings are blocked by fouling or burial in sediment or the pot substantially corrodes. Studies in Texas and Virginia estimate the functional life expectancy of crab pots to be two years (Voss, Browder, Wood, & Michaelis, 2015). Several factors influence these changes including gear material—vinyl coated vs non-coated—and location in the marine environment (e.g. salinity and corrosive power of the waters). Additionally, lost crab pots could hinder navigational safety or cause snags on other active fishing gear.

Table 2: *Number of crab pots recovered during the annual statewide "no-potting" period spanning Jan. 15 through Feb. 7. Cells with yellow shading designate years where commercial fishermen assisted with recovery activities. (Adapted from the North Carolina Division of Marine Fisheries Blue Crab Fishery Management Plan, Amendment 2, Table 11.14.2 revised annually with cleanup number from 2014 to present via personal communication with District Captains, in January of each year.)*

Crab Pots Recovered, 2003-2018				
Year	D1 - Northern District	D2 - Central District	D3 - Southern District	Total
2003	4047	900	127	5074
2004	7708*	527	108	635
2005	2168	N/A	N/A	2168
2006	1117	391	24	1532
2007	896	135	24	1055
2008	757	190	110	1057
2009	589	257	60	906
2010	570	154	24	748
2011	656	183	141	980
2012	684	160	295	1139
2013	451	445	545	1441
2014	364	64	226	654
2015	1004	149	155	1308
2016	753	80	70	903
2017	2,836	1,219	249	4304
2018	2,245	1,004	247	3496

*During the winter of 2004, the high number of lost pots encountered appears to be a result of Hurricane Isabel (Sept. 2003).

Results from a 2016 report on the effects of DFG in the Chesapeake Bay estimated derelict pots killed over 4.5 percent of the 73 million crabs harvested in 2014 and entrapped over 3.5 million white perch and nearly 3.6 million Atlantic croaker (Bilkovic, et al., 2016). Authors further estimated that removing just 10 percent of derelict pots in the 10 most heavily fished areas of Virginia and Maryland could increase blue crab harvest by 14 percent. Another study concluded that derelict crab pots do have an impact on salt marsh grass *Spartina alterniflora* but the effects are short term and do not pose a significant impact to this particular habitat in the North Carolina central coastal region (Urhin, 2011). Additionally, after the traps are no longer ghost fishing and are colonized by benthic communities they can become part of the marine environment.

Shellfish Mariculture Operations

Shellfish mariculture is defined as the "controlled cultivation of shellfish in confinement from seed size (≤1 inch) until harvest" (South Carolina Department of Natural Resources). Debris can be generated by shellfish mariculture operations that use cages, PVC, plastic mesh and lines that are placed on the bottom and in the water column.

Poorly operated shellfish mariculture operations can be a source of marine debris especially if operations are abandoned and not cleaned up. The cages and lines can break free if not maintained properly or if they are not completely secure during inclement weather events. In some instances, cages and lines are left when shellfish mariculture operations are abandoned. The commercial shellfish mariculture industry is currently being developed in North Carolina and minimal data exists on its contribution to marine debris. (Charron, Miller, Morris, Riley, & Weirich, 2018)

Figure 13. *Shellfish mariculture has become an important part of the coastal landscape in North Carolina. (photo by North Carolina Sea Grant).*

All major types of plastics are used throughout the mariculture shellfish industry and may contribute to marine debris such as polystyrene, polyethylene, polypropylene, polyamide, etc. Plastics are used in ropes and lines, pipes and fittings, netting, mesh, bags, cages and buoys. Other sources of debris from shellfish farms include wire mesh, wire cages, wood racks, wood pilings and anchors.

Figure 14. *Marine debris observed on an abandoned shellfish farm near Harkers Island, North Carolina (photo by James Morris).*

Shellfish mariculture debris can be a hazard for marine organisms and can lead to entanglement, be ingested or cause fatal injuries or health problems. Equipment that becomes abandoned or derelict, whether intentional or unintentional, can pose a risk to navigation and human safety. Improperly marked and maintained equipment, metal and netting can impact tourism, recreational activities and commercial fishing. Shellfish mariculture gear is different from commercial fishing gear in that it is concentrated in one location and can occupy many acres. Most shellfish farmers work to protect their gear and replace it whenever it becomes lost. Farmers understand that if debris escapes the confines of a shellfish mariculture farm, it reflects poorly on the industry and can lead to negative impacts (B. Charron, personal communications).

Responsible shellfish farmers have expressed concern that irresponsible growers in their industry that cause marine debris can tarnish the reputation of everyone in the industry (Charron, Miller, Morris, Riley, & Weirich, 2018). In North Carolina, commercial growers are working with federal and state agencies, universities and nonprofits to seek better ways to design and manage shellfish mariculture gear to reduce loss and create a greater business value. Other states are also working to develop shellfish best management practices, including California and Florida.

Monofilament Fishing Line and Netting

Monofilament fishing line is single strand, strong plastic line that is used in both recreational and commercial fisheries in North Carolina Monofilament can become marine debris when the line is broken by snags, propellers, fish or when it is disposed of improperly. Discarded fishing line can cause injury and death to birds, turtles and marine mammals such as dolphins, whales and seals. Line can likewise entangle boat propellers, potentially causing motor damage. Gillnets, or a wall of netting, can also entangle target and non-target species when they become lost or abandoned in the inshore or nearshore waters of North Carolina

Figure 15. *This bottlenose dolphin calf entangled in monofilament fishing line died during a rescue attempt in the Newport River, January 2005*

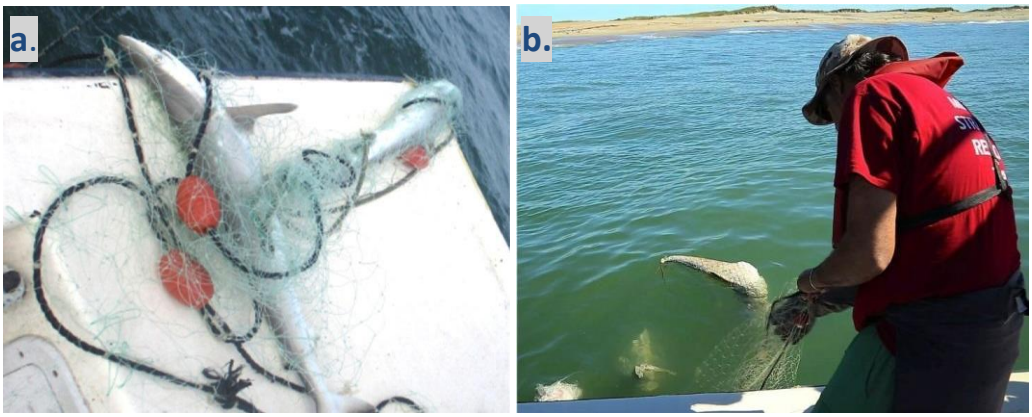

Figure 16. *a) Part of the bycatch (sharks) from a derelict ~1.1 mile long gill net that was found on 19 May 2016 about 100 yards off of the ocean side of Shackleford Banks, North Carolina (photo by Keith Rittmaster); b) Cobia bycatch from a derelict gill net found on 20 October 2017 approximately 100 yards off of the ocean side of Shackleford Banks, North Carolina. (photo by Keith Rittmaster).*

Current and Past Initiatives and Policies

The North Carolina Coastal Federation's Lost Fishing Gear Recovery Project began in northeastern North Carolina waters in 2014 with funding from NOAA and North Carolina Sea Grant. In 2017, this project expanded statewide through funding provided by the North Carolina General Assembly. The expansion of the program enabled the federation to hire more commercial fishermen to increase the number of lost pots recovered.

Figure 17. *a) A commercial fisherman removes a lost crab pot from the water as part of the Crab Pot Removal Program. (Photo by Chris Hannant) B) A dead loggerhead sea turtle that was entangled in the buoy line of a derelict crab trap in Middle Marsh, Rachel Carson Reserve, Carteret County. (Photo by Paula Gillikin, North Carolina Coastal Reserve).*

North Carolina has regulations for abandoned or derelict mariculture gear through state littering policies (North Carolina G.S. 14-399). Commercial gear is also addressed under 15A NCAC 03I .0105, which states that:

> (a) *It is unlawful to leave stakes, anchors, nets, buoys, or floating devices in any coastal fishing waters when such devices are not being employed in fishing operations except as otherwise provided by rule or General Statute.*

These regulations are enforced by the North Carolina Division of Marine Fisheries. The North Carolina Coastal Federation, NOAA, and North Carolina Sea Grant are also currently working with shellfish growers to develop a set of Voluntary Best Management Practices for shellfish farming operations.

Proper disposal and recycling of monofilament fishing line is encouraged through the North Carolina Monofilament Recycling Program (NCMRP). The NCMRP collects monofilament from 42 recycling bins located throughout the North Carolina coast at fishing piers, marinas, bait and tackle shops, dive shops and beaches (Figure 18). Approximately 2,700 miles of monofilament fishing line has been collected and recycled by the NCMRP since 2007. A graph of the cumulative miles of fishing line recycled in North Carolina from February of 2007 to August of 2017 is provided in Appendix A. Other monofilament recycling programs are known to exist in North Carolina, but data about these programs is not presented in this document.

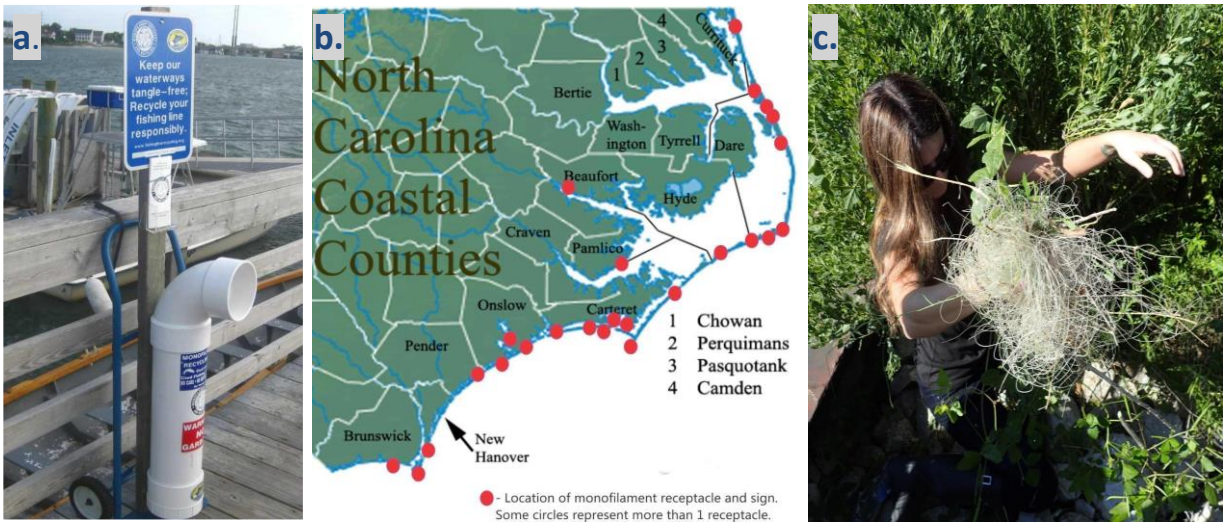

Figure 18. *a) Monofilament collection site (photo by Keith Rittmaster); b) Location of monofilament receptacles and signs along coastal North Carolina. Some circles represent more than 1 receptacle. (Photo by Keith Rittmaster); c) Monofilament line found during working shoreline cleanup in Rodanthe 2015 during NCMDS Cleanup. (Photo by Bonnie Monteleone).*

Abandoned and Derelict Vessels

NOAA defines abandoned and derelict vessels (ADVs) as "vessels in significant disrepair that may pose a threat to the public or the environment. 'Derelict' frequently refers to vessels that are dilapidated with an identifiable owner, while 'abandoned' vessels are those where the owner is unknown or has surrendered rights of ownership." The state of North Carolina does not legally define "derelict" vessels, but does provide a definition for an "abandoned" vessel under North Carolina Gen. Stat. § 75A-2(1):

> "Abandoned" means a vessel that has been relinquished, left, or given up by the lawful owner without the intention to later resume any right or interest in the vessel. ADVs can alter marine and estuarine habitats, become navigational hazards, and be unsightly.

As identified in the 2006 NOAA Report, "Review of State Abandoned and Derelict Vessel Removal Programs," there are numerous reasons for the abandonment of vessels. These causes include storm events, economic stress, financial issues of individual owners, absentee owners that do not maintain or monitor their vessel, accidental groundings, high cost of proper vessel disposal or retrofitting of old vessels and low salvage cost recovery (e.g., low scrap metal prices) (NOAA, 2006).

ADVs have been documented to cause physical impacts in subsurface marine habitats, benthic habitats and seagrass beds. They can also lead to toxic impacts in aquatic habitats (U.S. Environmental Protection Agency, 2011; Lord-Boring, Zelo, & Nixon, 2004). ADVs can also cause navigational hazards as they interfere with boating traffic (NOAA, 2016).

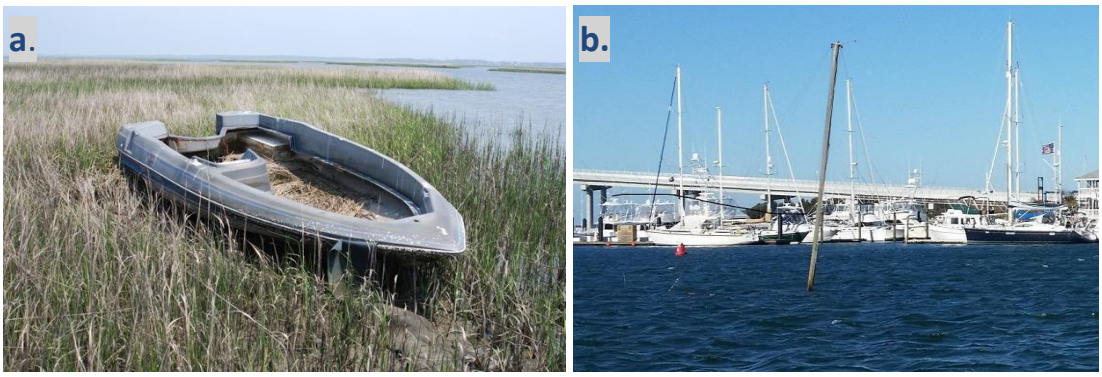

Figure 19. *a) A small boat stripped of propulsion, rigging, metal hardware and electronics, was improperly disposed of in the waterway near Beaufort, North Carolina. The vessel caused erosion and marsh vegetation damage; b) A sunken and abandoned sailboat in Town Creek, Beaufort, North Carolina. The vessel was impeding navigation into a marina (photos by North Carolina Coastal Reserve).*

A comprehensive mapping study of derelict and abandoned vessels has not been conducted for the coast of North Carolina However, there are examples of organizations that have conducted partial ADV mapping surveys or collected continuous information on ADVs within their management areas (Hills, 2007).

For example, from 2007 to 2017, staff at the 2,300 acre Rachel Carson Reserve in Beaufort, North Carolina, documented at least five abandoned or derelict sailing vessels and one houseboat that either washed ashore or sank. This does not include vessels that were sunk prior to 10 years ago or ones that have been abandoned and are currently securely tied or anchored within or near the Reserve boundaries. This also does not include vessels that have washed ashore during hurricanes and were reclaimed by the owners.

The Rachel Carson Reserve comprises only a small fraction of North Carolina's 2 million acres of estuarine habitat, thus the number of vessels that have become ADVs during the past 10 years along the entire coast can reasonably be estimated at least in the hundreds. As of November 2018, this number has increased by at least a few hundred due to vessels that were displaced during and subsequently abandoned after Hurricane Florence (P. Gillikin, personal communication, November 16, 2018).

Current and Past Initiatives and Policies

Three federal agencies with statutory authorities are responsible for addressing ADVs in North Carolina waters under specific circumstances. The U.S. Army Corps of Engineers (USACE) maintains federal navigation channels and is responsible for removing vessels within a federal channel if the owner cannot be identified and/or is non-responsive. The U.S. Coast Guard is responsible for the removal of fuels, fluids and other potentially toxic substances that could emanate from debris, including abandoned vessels but does not necessarily remove the vessel itself. The Federal Emergency Management Agency only funds waterway debris removal during declared federal disasters and in non-federal waterways when another federal agency does not have authority to fund the activity. However, based on the state's experience with Hurricane Florence (September 2018) response, the state's current laws will allow for removal of

hazardous materials from the vessels, but will not allow for removal of the vessel itself from the environment.

A formal program, law or dedicated funding source does not exist that provides oversight, regulatory authority, or financial support for the removal or disposal of ADVs in North Carolina. However, there are state laws that authorize citizens to take ownership of abandoned vessels and provide state and local governments to take action.

For a citizen to take ownership of abandoned vehicles, including vessels, it must be proven that the vessel is abandoned according to North Carolina G.S. § 75A-5(i)(2) and North Carolina A.C. 15A. Citizens can pursue taking ownership of an ADV through an established process administered by the North Carolina Wildlife Resources Commission, the state agency responsible for vessel titling and registration. If a citizen takes ownership of an abandoned vessel, they become responsible for the vessel and associated costs. If an owner abandons a vessel, there is no statutory legal structure that requires an owner to remove the vessel. However, there are criminal charges for littering (North Carolina Gen. Stat. § 76-40(a)) that can be enforced by the North Carolina Department of Environmental Quality when a vessel is abandoned in navigable waters of the state. State agencies can also pursue criminal action and provide support to the Army Corps of Engineers when abandoned boats are left in public waterways (North Carolina G.S. § 143- 355(b)(5))).

Local governments can regulate abandoned boats and waterways within their jurisdictions. Counties can be authorized by the state in accordance with North Carolina G.S. 153A-132 to establish an ordinance prohibiting the abandonment of junked vehicles, including vessels, within county jurisdictions. Through this legislation, counties can enforce such ordinances and remove and dispose of abandoned vessels. The state first granted Dare and Brunswick counties the authority in 2013 to address abandoned vessels. The general statute was amended in 2015 to include all coastal-area counties. Municipalities can establish similar ordinances in accordance with North Carolina G.S. 160A-303.2.

At least five local governments along the coast have passed ordinances related to abandoned and derelict vessels. Pursuant to North Carolina G.S. 160A, the Town of Wrightsville Beach prohibits abandoned vessels and permanent moorings and controls where vessels can anchor and for how long. The purpose of this ordinance is to protect water quality, prevent abandonment of boats and enables the town to dispose of boats that do become abandoned. Brunswick County established several ordinances (Chap. 1-9, Article IX) pursuant to G.S. 153A-132 related to the prevention and management of ADVs. Dare County has a similar law. Partly inspired by Brunswick County's ordinance, Hyde County adopted an ordinance (Chapter 26, Sec. 26-4) in the spring of 2018 to prohibit the abandonment of vessels in navigable waters of Ocracoke Harbor. Most recently, the Town of Beaufort, NC passed a Navigable Waterways Ordinance (Title IX, Chap. 96) that will help prevent and dispose of abandoned and derelict vessels. One of the primary challenges to effectively prevent and remove ADVs from all North Carolina waters is the lack of specific statewide policy that governs removal, disposal, and dedicated and sustained funding to support such efforts; only local jurisdictions with relevant ordinances and funding are able to effectively govern and respond to ADVs. This challenge was highlighted during the state's response to Hurricane Florence, when there was an opportunity

to request federal support for removing hundreds of displaced vessels from the environment. State laws were found to be inadequate for removing private vessels and potentially disposing of abandoned ones (P. Gillikin, personal communication, November 16, 2018).

Current federal and state laws related to ADVs are administered by various agencies and jurisdictions, thus making it difficult and sometimes almost impossible to remove ADVs or prevent them from becoming a problem if a local law governing ADVs does not apply. In 2015, North Carolina Sea Grant and the Eastern Carolina Council of Governments sponsored a collaborative meeting with state agencies, local governments and members of the North Carolina General Assembly to discuss the problem of ADVs and priority topics that needed to be addressed to improve ADV prevention and removal. Four of the twelve topics discussed were identified as priorities: prevention of ADVs, enacting appropriate state legislation and local laws, identifying dedicated funding sources for ADV removal and establishing a comprehensive ADV prevention and removal program.

Storm Debris

Storm events can significantly intensify the amount of debris that litter coastal waterways from all sources. A 2016 NOAA report concludes how potential storm events can increase the amount of marine debris (NOAA, 2016):

> "North Carolina's coastline, dominated by over 300 miles of barrier islands, is vulnerable to severe weather events and associated waterway debris. Flooding and erosion from waves and high water driven by coastal storms and hurricanes have the potential to generate large amounts of debris that may enter sounds, estuaries and wetlands (NCEM, 2012)."
>
> "...These coastal counties and the barrier islands that extend east into the Atlantic Ocean are especially vulnerable to the impacts of severe weather and associated waterway debris. Between 1960 and 2008, North Carolina's coast was ranked second only to Florida in number of hurricane strikes along the east coast (U.S. Census Bureau, 2010)."

Storm debris can alter habitat, harm wildlife and endanger public health. Larger pieces of wooden debris that break off from docks and piers often litter shorelines after larger storm events. Hurricane Florence (September 2018) caused widespread destruction of docks and piers leaving an expansive scatter of chemically treated lumber behind. Proper handling and disposal of treated wood is particularly important because ingestion of the chemicals or inhalation of the smoke originating from burning the wood (this is illegal; North Carolina Administrative Code 15A NCAC 2D.1900) can be dangerous to human health (Environmental Protection Agency, 2016). Studies have found that storm events can intensify damage done to seagrass beds through erosion caused by abandoned and derelict vessels (Lord-Boring, Zelo, & Nixon, 2004). Debris lost from shellfish farms is also most often attributed to coastal storms when stress and loads exceed engineering thresholds of culture gear or anchoring systems.

Figure 20. *Marine debris litters the shore in Nags Head, North Carolina, after Hurricane Sandy in 2012 (photo by North Carolina Coastal Federation).*

Current and Past Initiatives and Policies

In North Carolina there are building codes for docks and piers identified by the Coastal Area Management Act (CAMA) and the U.S. Army Corps of Engineers. These regulatory entities require permits to build any new docks or piers and enforce compliance of regulations to help minimize storm debris. In regards to marine debris, the codes state that:

> "All piers and docking facilities must meet the general CAMA rules for coastal wetlands, estuarine waters and public trust areas and the following specific regulations {15A NCAC 7H .0208(b)(6)}: Piers in existence on or before July 1, 2001, may be braced with additional pilings and crossbeams to prevent or minimize storm damage, as long as the pilings do not extend more than 2 feet beyond either side of the pier."

Permits and regional conditions issued by the U.S. Army Corps of Engineers in the Wilmington District require that all docks and shoreline stabilization measures (bulkheads) be kept in good repair. When such structures become damaged, they should either be repaired or removed. However, there is little enforcement of this federal permit condition leaving the decision about cleaning up a storm damaged structure to property owners.

The North Carolina Incident Waterway Debris Response Guide: Comprehensive Guidance Document developed in 2016, provides additional information on storm debris and is used as a guideline for stakeholders to follow after storm incidents or emergencies which contribute to large amounts of marine debris.

PREVENTION, REDUCTION, AND RESEARCH

The assessment team identified more than 100 North Carolina government, business, academic and nonprofit organizations that are working to reduce, prevent or research the impacts of marine debris through mission oriented programming, stewardship projects and/or legal mandates.

A table of organizations and their roles in managing marine debris is found in Appendix C. The table includes all organizations that participated in the 2017 online stakeholder survey in addition to stakeholders that have been identified through direct contact, participation in the North Carolina Marine Debris Symposium, or are listed as a contact in the North Carolina Incident Waterway Debris Response Guide.

A challenge to constructing and maintaining a comprehensive list of marine debris stakeholders and having them work together effectively is the lack of a program or agency that coordinates marine debris reduction and prevention activities statewide.

Based on the 2017 survey, organizational affiliations were as follows: state government (27 percent), non-profit and volunteer (23 percent), local government (18 percent), academia (14 percent), business and industry (11 percent) and federal government (7 percent). The survey revealed that a majority of stakeholders conduct education and outreach activities in some manner. These results suggest that stakeholders regard education and outreach as a priority in reducing marine debris and/or their missions and program resources are best aligned to focus on these efforts. Between 42 percent and 51 percent of respondents were also involved in cleanup activities, whether coordinating or participating in a cleanup, or referring citizens or groups to a resource that can help them with cleanup activities. Thirty-five percent of the respondents also identified that they were engaged in advocacy. Almost a quarter (27) responded that they are engaged in waste management and approximately 20 percent of respondents identified as being engaged with developing policies and laws. Fewer respondents were engaged in research and technology. See Figure 21 for a summary of stakeholder activities.

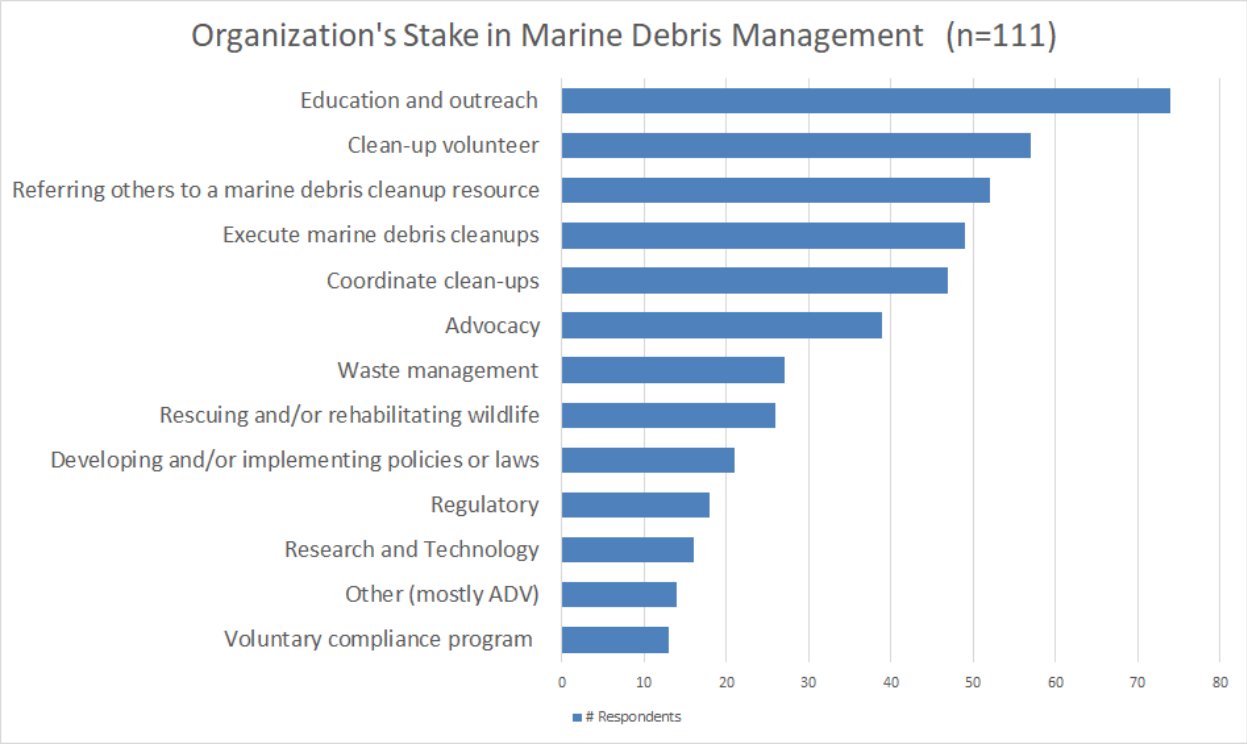

Figure 21. *Results from the 2017 marine debris stakeholder survey which highlight various stakeholders' roles in addressing marine debris. Respondents were asked to identify what best describes how their organization is involved with marine debris management and could check all that applied.*

When asked which type of marine debris their organization focused on managing or addressing (and allowed to check all that applied) nearly 75 percent of respondents identified with addressing consumer generated debris, 44 percent with storm debris, 40 percent with abandoned and derelict fishing gear and 31 percent with debris that had the potential to cause pollution (oil, fuel, etc.).

Organized Removal Efforts

Coastal area cleanups, including roadside, shoreline, beach, waterway and underwater are being conducted in coastal communities on a regular basis by state, local government and non-profit organizations. This is also represented in the table of organizations and their roles in managing marine debris in Appendix B.

Some participating organizations include the North Carolina Department of Transportation by way of Adopt-a-Highway, Keep America Beautiful affiliates, local government groups (formerly known as North Carolina Big Sweep coordinators), Surfrider Foundation chapters (including Adopt a Beach program), North Carolina Coastal Federation, North Carolina Coastal Reserve and National Estuarine Research Reserve, Sierra Club chapters, Plastic Ocean Project, North Carolina Aquariums and more. A variety of community programs are also taking place including social media campaigns such as #obx5minutebeachcleanup and #debrisfreeNC. Many

organizations are recording data on debris that is removed but not all organizations are using the same database. The North Carolina Marine Debris Symposium has encouraged the use of the marine debris tracker app for beach cleanups in the state.

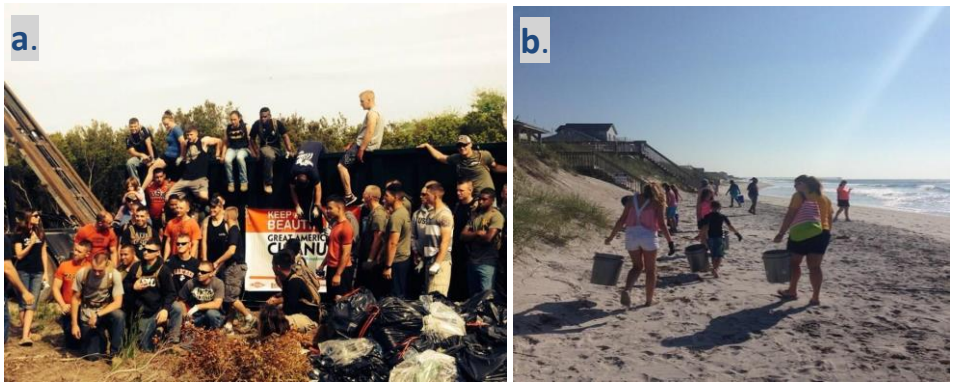

Figure 22. *a) U.S. Marine Corps New River Volunteers from the Keep Onslow Beautiful - Great American Cleanup at North Topsail Beach, Intracoastal Waterway Cleanup with collected debris (photo by Wes Rider); b) Onslow County School Group Cleanup using reusable buckets 2016 (photo by Lisa Rider).*

The North Carolina-based nonprofit Plastic Ocean Project (POP) has been partnering with the University of North Carolina Wilmington (UNCW) to collect and research plastics in the North Atlantic since 2012. POP researchers recognized Sargassum (a type of seaweed) as an aggregate for plastic marine debris. Sargassum is an essential marine habitat and therefore plastic in the Sargassum increases the possibility for marine life to either ingest or get entangled in plastic marine debris.

Coming to this realization, POP and collaborators developed a one day Fishing 4 Plastic (F4P) Tournament. By enlisting the help of charter fishermen, teams of volunteers travel offshore to gently remove plastic with nets from Sargassum mats that form less than 50 miles offshore near the Gulf Stream (B. Monteleone, personal communication, January 12, 2018).

In 2017, POP and collaborators held the first Fishing 4 Plastic (F4P) Tournament in Beaufort, North Carolina, engaging over 60 volunteers that removed nearly 400 pounds of marine debris. The marine debris that was collected have been used to create educational sculptures and featured in aquariums and other public spaces.

Figure 23. *Marine debris found during the Fishing 4 Plastics Tournament offshore Morehead City, North Carolina (photo by Bonnie Monteleone).*

Funded Marine Debris Projects in North Carolina

North Carolina organizations such as universities, schools, nonprofits, state and federal departments have received and allocated funding for marine debris monitoring, removal and research. Funding for marine debris removal, prevention and research in North Carolina has been provided through federal, state, local and private sources.

Several projects of varying scope have been federally funded by NOAA in recent years. North Carolina state agencies and State Appropriations from the North Carolina General Assembly have also contributed to large scale projects. Smaller volunteer cleanups are often funded by local community sponsors. The appropriation of funds to support marine debris removal and prevention suggests that government and private agencies alike are recognizing a need to address this issue in our state.

The following is an outline of projects funded in recent years, many of which received support through competitive funding awards. This list of funding sources is not exhaustive. It should be noted that a number of North Carolina organizations receive marine debris funding through operating budgets and private grants and are not reflected here.

State Funding

State Appropriations:

- *Developing Fishermen-led Crab Pot Recovery Program in North Carolina*
  Lead: North Carolina Coastal Federation
  Removal Funding (FY 17; $100,000)

North Carolina Sea Grant:

- *Developing Fishermen-led Crab Pot Recovery Program in North Carolina*
  Lead: North Carolina Coastal Federation
  Removal Funding (FY 15; $97,890)

- *A Pilot Program to Work with Commercial Fishermen to Recycle Derelict Crab Pots into Oyster Reefs*
  Lead: North Carolina Coastal Federation
  Removal Funding (FY 13; $18,721)

Federal Funding

The NOAA Marine Debris Program is authorized by Congress through the Marine Debris Act and funds projects focused on marine debris removal, research, and prevention. The Program mission is “to investigate and prevent the adverse impacts of marine debris”. Since 2013, support for North Carolina projects totaled over $670,000 with project awards ranging from approximately $30,000 to $290,000.

The following is a list of projects funded from 2013 to 2017:

- *Debris removal in Beaufort Harbor and the North Carolina National Estuarine Research Reserve* Leads: Town of Beaufort, North Carolina and North Carolina National Estuarine Research Reserve Removal Funding (FY 18-19; $67,889)

- *AquaDebris: Site restoration and habitat recovery assessment of shellfish aquaculture in North Carolina*
  Lead: North Carolina Coastal Federation
  Removal Funding (FY 17; $64,474)

- *Microplastic ingestion by the black sea bass, Centropristis striata: An assessment of potential impacts on health of an Atlantic commercial fish species*
  Lead: University of North Carolina Wilmington
  Research Funding (FY 17; $289,098)

- *Using Unmanned Aerial Systems to Inform Marine Debris Removal Strategies and Monitor Habitat Recovery in the Rachel Carson Reserve*
  Lead: North Carolina National Estuarine Research Reserve
  Removal Funding (FY 16; $40,768)

- *Developing Fishermen-led Crab Pot Recovery Program in North Carolina*
  Lead: North Carolina Coastal Federation
  Removal Funding (FY 15; $93,047)

- *Traveling Through Trash: Coastal Migratory Animal Encounters with Marine Debris*
  Lead: University of North Carolina - Wilmington
  Prevention Funding (FY 15; $29,615)

- *A Pilot Program to Work with Commercial Fishermen to Recycle Derelict Crab Pots into Oyster Reefs*
  Lead: North Carolina Coastal Federation
  Removal Funding (FY 13; $35,576)

- *Investigating selective grazing by copepods of virgin and weathered microplastics contaminated with PBT substances*
  Lead: Sea Education Association, Inc.
  Research Funding (FY 13; $117,751)

DISCUSSION AND CONCLUSION

Marine debris is a demonstrated problem in North Carolina and is formally acknowledged as such by a majority of North Carolina marine debris stakeholders as suggested by results of the online survey and public and lawmaker reactions to the almost 400 vessels that were recently

displaced by Hurricane Florence.

The survey indicates that there are a variety of marine debris stakeholders, from government to business to nonprofit and beyond, that are currently engaged in and/or willing to participate in marine debris management activities. Many of these organizations have missions or management documents that include direct or indirect mandates or guidance to protect the environment from marine debris. Data from the online stakeholder survey supports the need for developing a formal plan to address marine debris in coastal North Carolina.

This document reveals that the types and impacts of debris found in North Carolina are similar to those found nationally and internationally, illustrating that the issue is of both local and global importance. Impacts of marine debris are often shared across debris types; however, there are unique effects between different debris types such as impacts on protected species, primarily associated with abandoned fishing gear and consumer debris, versus submerged navigation hazards, often associated with abandoned vessels. Likewise, opportunities and challenges in addressing different debris types are often similar (e.g. better laws and/or enforcement), but can be very unique and specific (e.g. developing best management practices for water-based industries) according to the debris type. There are a variety of management actions currently being implemented to address debris and many more that are needed to address the problem and assess efficacy of those efforts.

In North Carolina, one of the most noticeable types of marine debris, abandoned vessels, are currently an issue of focus for both local governments and the state (Coastal Review Online, 2018; North Carolina General Assembly, 2018). Almost 400 vessels were left displaced along the coast after Hurricane Florence impacted North Carolina in mid-September of 2018. Many of the vessels still remain in the environment in addition to the abandoned and derelict vessels that existed prior to the hurricane. State departments involved in the emergency response were unable to request federal assistance in removing the vessels, as there were questions about the state's legal authority to handle and potentially dispose of private vessels (P. Gillikin, personal communication, November 16, 2018). The challenges associated with the Hurricane Florence response and this legal barrier provide the state an opportunity to evaluate currents laws related to vessels in preparation for future natural disasters and also for addressing abandoned and derelict vessels in general.

To advance addressing the marine debris concerns outlined in this document in a more holistic, strategic and coordinated way, a process (initially led by the writers of this document) is underway to develop a coast-wide marine debris action plan. This process has been and will continue to engage many of the stakeholders listed in this document.

For more information, contact the North Carolina Coastal Federation at 252-393-8185.

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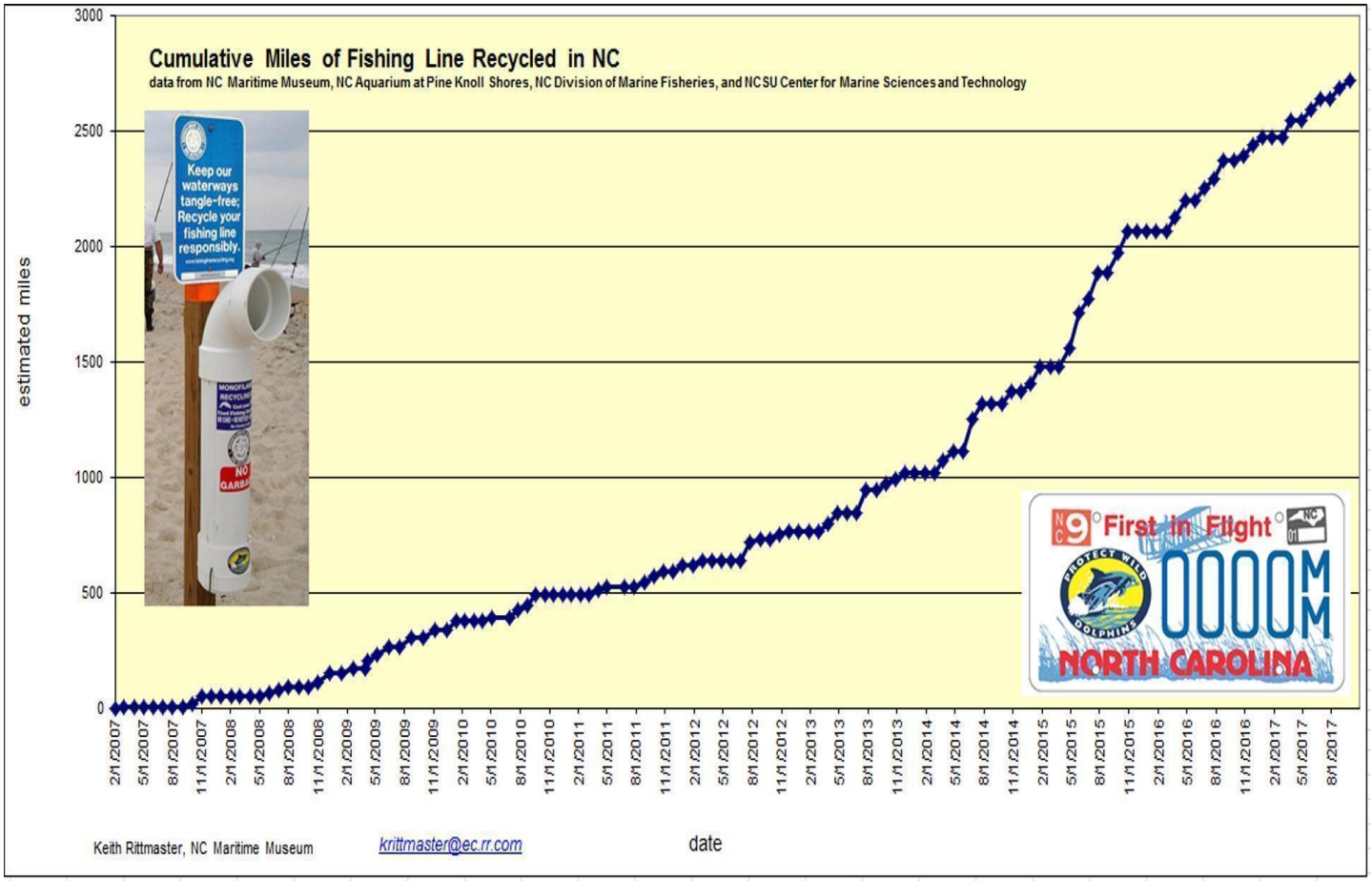
APPENDICES

Appendix A: Graph showcasing the cumulative miles of fishing line recycled in North Carolina from February of 2007 – August of 2017. Image provided by Keith Rittmaster.



Appendix B: Summary of North Carolina marine debris stakeholder involvement in marine-debris related activities

Organization or Agency	Involvement						
	Education and Outreach	Research and Technology	Cleanups	Policy or Advocacy	Enforcement	Solid Waste Management	Wildlife Rescue or Rehabilitation
Association of Plastics Recyclers (APR)	X	X		X			
Atlantic Coast Marine Group, Inc. dba TowBoatUS			X	X			X
Bald Head Island Conservancy	X		X				X
Blockade Runner Beach Resort	X		X	X	X	X	
BlueTube, Inc.	X						
Brunswick County Government	X			X		X	
By the Brook Productions LLC	X			X			
Carolina Ocean Studies	X						
Carteret County Big Sweep	X		X				
Carteret County Crossroads	X		X	X		X	
Carteret County Schools - East Carteret High School	X		X	X			
City of New Bern						X	
City of Southport				X			
City of Wilmington	X		X	X		X	
Clements Marine Construction Inc.					X		
Coastal Carolina Community College	X						
Crystal Coast Waterkeeper	X		X	X			
Crystal Coast Waterkeeper/Coastal Carolina Riverwatch	X	X	X	X	X	X	X
Dare County	X		X				
Department of Environmental Management	X		X	X		X	
Duke University	X	X	X	X			
Duke University Environmental Law and Policy Clinic	X	X		X			X
Emerald Isle Sea Turtle Patrol			X				
Emerald Isle Sea Turtle Protection Program- permit	X		X				X

Organization or Agency	Involvement						
	Education and Outreach	Research and Technology	Cleanups	Policy or Advocacy	Enforcement	Solid Waste Management	Wildlife Rescue or Rehabilitation
Fort Caswell: Environmental Stewardship Program	X		X			X	X
Fort Macon Sail and Power Squadron			X				
Friends of Pleasure Island State Park	X		X	X			
Friends of the Reserve			X	X			
Halyburton Park	X						
Keep Onslow Beautiful	X		X		X	X	
League of Women Voters- Dare County	X		X	X			
More Recycling	X	X		X			
National Park Service- Cape Hatteras National Seashore	X		X		X	X	X
National Park Service- Cape Lookout National Seashore	X		X	X	X	X	X
North Carolina Coastal Federation	X		X	X			
North Carolina DCR- North Carolina Aquariums - Fort Fisher	X		X				X
North Carolina DCR- North Carolina Aquariums - Jennette's Pier	X		X				X
North Carolina DCR- North Carolina Aquariums - Pine Knoll Shores	X		X	X		X	X
North Carolina DCR- North Carolina Aquariums - Roanoke Island	X		X				X
North Carolina DCR- North Carolina Historic Sites - Brunswick Town/Ft. Anderson State Historic Site	X	X	X				
North Carolina DCR- North Carolina Maritime Museum - Beaufort	X		X				X
North Carolina DCR- North Carolina State Parks - Fort Fisher State Recreation Area	X		X		X		X
North Carolina DCR- North Carolina State Parks - Fort Macon			X				

Organization or Agency	Involvement						
	Education and Outreach	Research and Technology	Cleanups	Policy or Advocacy	Enforcement	Solid Waste Management	Wildlife Rescue or Rehabilitation
North Carolina DCR- North Carolina State Parks - Hammocks Beach	X		X				X
North Carolina DCR- North Carolina State Parks - Jockey's Ridge	X		X	X			X
North Carolina DEQ- Albemarle-Pamlico National Estuary Partnership			X				
North Carolina DEQ- North Carolina Coastal Reserve and National Estuarine Research Reserve	X		X	X			X
North Carolina DEQ- North Carolina Division of Coastal Management					X		
North Carolina DEQ- North Carolina Division of Environmental Assistance and Customer Service	X	X	X			X	
North Carolina DEQ- North Carolina Division of Marine Fisheries		X	X		X		
North Carolina DEQ- North Carolina Division of Marine Fisheries			X		X	X	
North Carolina DEQ- North Carolina Division of Waste Management, Solid Waste Section						X	
North Carolina DEQ- North Carolina Division of Waste Management, Solid Waste Section	X		X	X	X	X	
North Carolina DEQ- North Carolina Division of Waste Management				X		X	
North Carolina DEQ- North Carolina Division of Water Resources	X		X	X		X	
North Carolina DOT- State Maintenance Operations			X				
North Carolina DPS- North Carolina Emergency Management	X		X	X		X	
North Carolina Sea Grant	X	X	X	X			

Organization or Agency	Involvement						
	Education and Outreach	Research and Technology	Cleanups	Policy or Advocacy	Enforcement	Solid Waste Management	Wildlife Rescue or Rehabilitation
North Carolina Sentinel Site Cooperative/North Carolina Sea Grant			X				
North Carolina State University	X	X					
North Carolina State University, Center for Marine Sciences and Technology	X		X				
North Carolina State University, College of Veterinary Medicine, Center for Marine Science and Technology	X						X
North Carolina WRC- Law Enforcement Division				X	X		X
North Carolina WRC- Wildlife Diversity Program	X	X	X				X
NCSU- North Carolina Cooperative Extension	X		X				
NCSU- North Carolina Cooperative Extension - NC Big Sweep	X		X				
NOAA Fisheries- Habitat Conservation					X		
NOAA- Office of Response and Restoration	X	X	X	X		X	
Oak Island Beach Preservation Society	X		X				
Oak Island Sea Turtle Protection Program	X			X			X
Ocean Conservancy	X		X	X			
Ocean Friendly Establishments-Crystal Coast	X						
Onslow County Schools - Dixon Middle School AVID 8th	X						
Onslow Solid Waste Department	X		X		X	X	
Parrot Heads of North Carolina			X				
Peltier Creek Marina Inc.			X	X			X
Plastic Ocean Project, Inc.	X	X	X	X	X		
Science by the Sea	X		X				
Sea Turtle Hospital (KBSTRRC)	X		X	X			X
Sierra Club- Croatan Group	X		X	X			

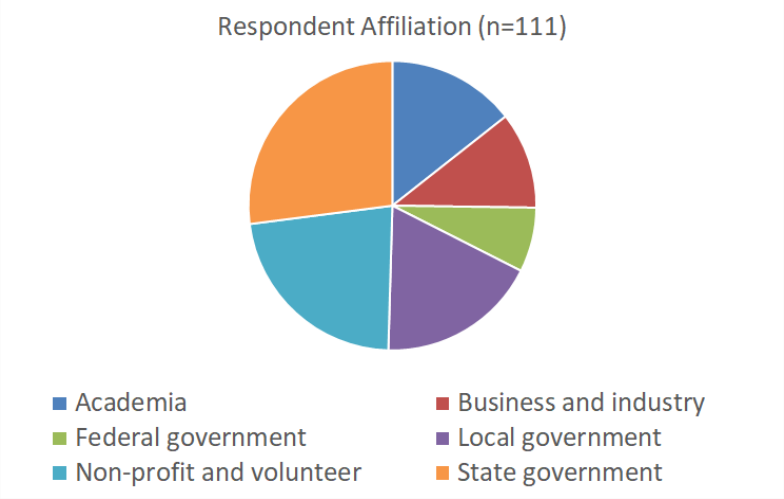
Organization or Agency	Involvement						
	Education and Outreach	Research and Technology	Cleanups	Policy or Advocacy	Enforcement	Solid Waste Management	Wildlife Rescue or Rehabilitation
Sonoco Recycling - Jacksonville						X	
Sound Rivers	X						
Sturgeon City	X		X				
Surfrider Foundation- Cape Fear	X		X	X	X		
Surfrider Foundation- Outer Banks Chapter	X		X	X			
Town of Atlantic Beach			X				
Town of Beaufort	X		X	X	X	X	
Town of Cedar Point	X		X	X	X		
Town of Leland			X				
Town of Manteo			X	X	X		
Town of Morehead City			X	X			
Town of Oriental	X		X	X		X	
Town of Swansboro			X				
Town Of Wrightsville Beach						X	X
UNC Chapel Hill and UNC Coastal Studies Institute	X		X				
UNC Institute of Marine Sciences	X	X		X			
UNCW Marine Quest	X		X				
US Army Corps of Engineers- Navigation Section			X				
USCG Auxiliary- Flotilla 09-11	X		X				
USFWS- Alligator River and Pea Island National Wildlife Refuges	X		X			X	X
USFWS- Cedar Island National Wildlife Refuge	X		X			X	
Wrightsville Beach Keep It Clean	X		X				X

Appendix C: 2017 North Carolina Marine Debris Stakeholder Survey Results

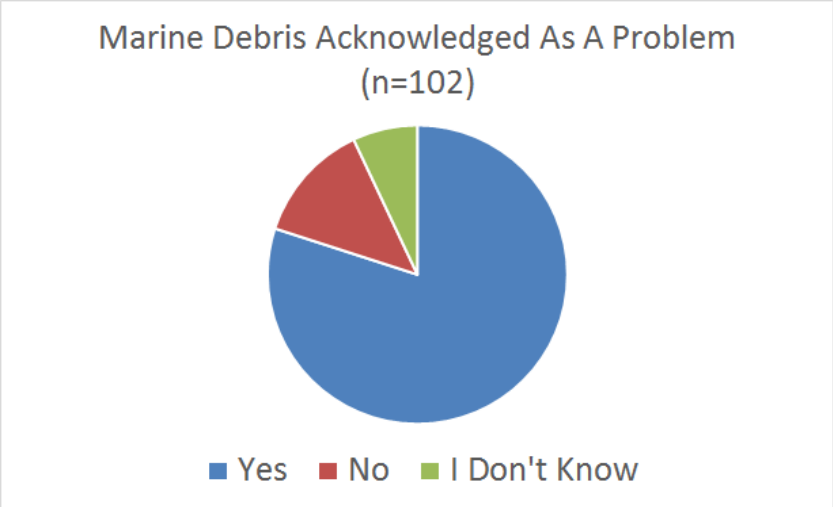
As part of our assessment we conducted an online survey to more fully capture which and how organizations were working on marine debris issues in the state. The survey was open for 23 days from Aug. 15 to Sept. 5, 2017.

A link to the survey was sent directly to a list of contacts compiled from various sources including past North Carolina Marine Debris Symposium attendees, a 2015 stakeholder group that met to address abandoned and derelict vessels and others known to be involved with marine debris projects. The North Carolina Coastal Federation also advertised the survey in a blog, as did North Carolina Sea Grant and the NCNERR Coastal Training Program distributed it through their listservs. A total of 111 responses were received. Findings are provided, below.

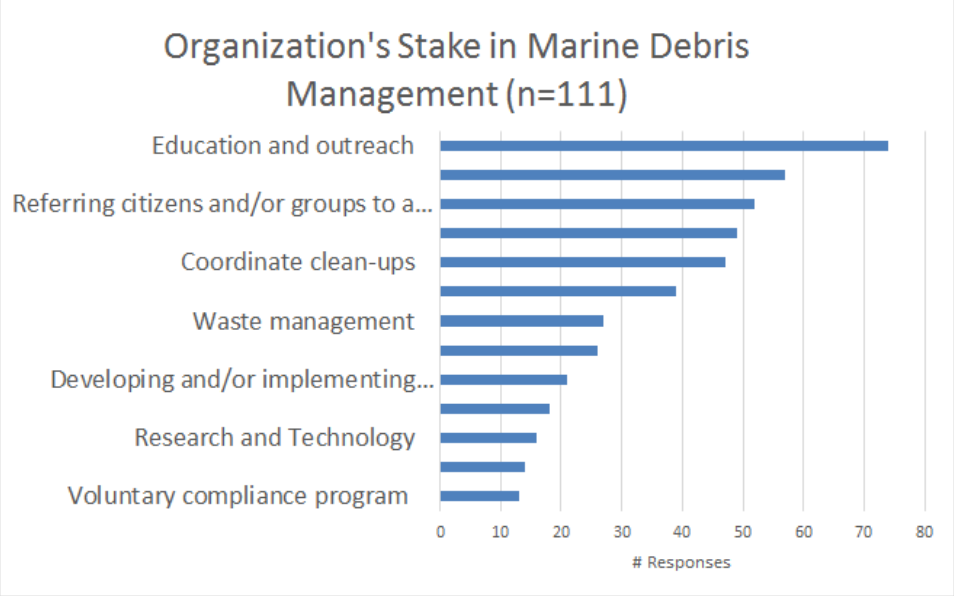
Question: Which best describes your affiliation?



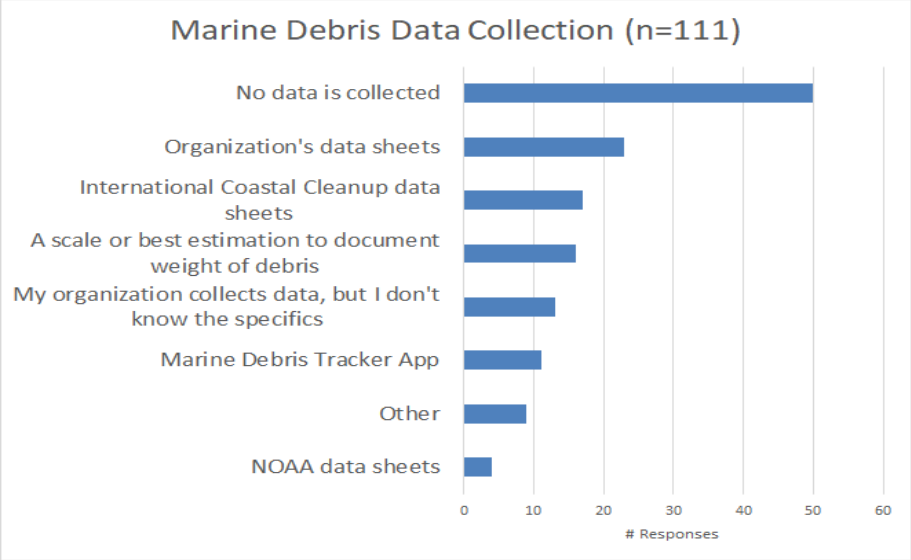
Question: Is marine debris an issue that your organization formally recognizes as a concern or priority (e.g. in organizing documents, management plans, strategy documents, policies, laws, etc.)?



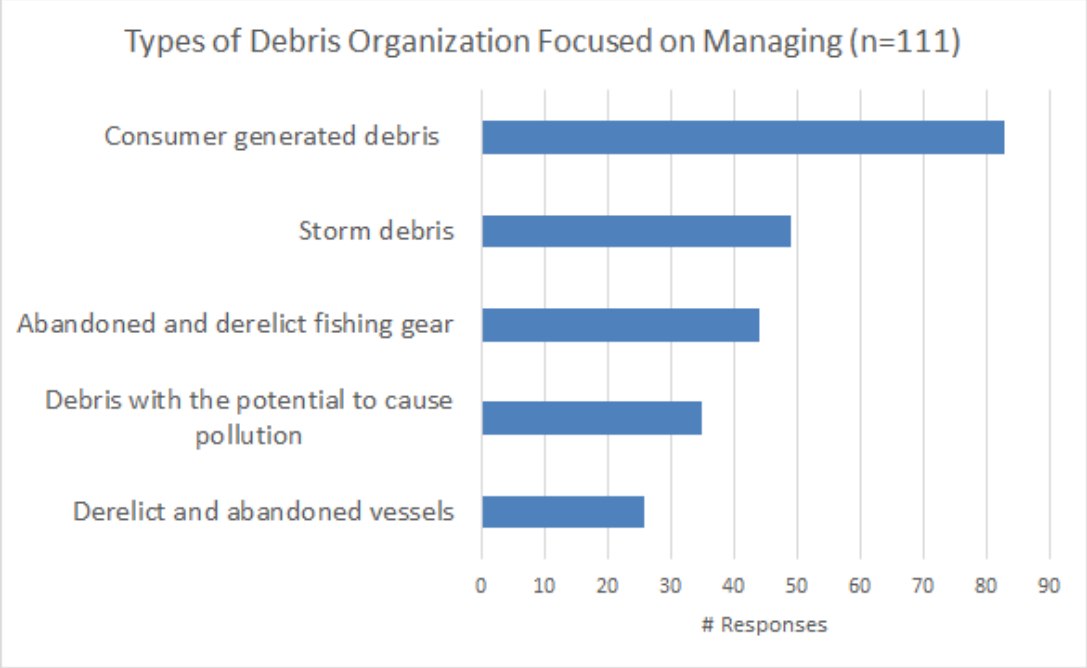
Question: What best describes your or your organization's stake in marine debris management in NC? (Check all that apply)



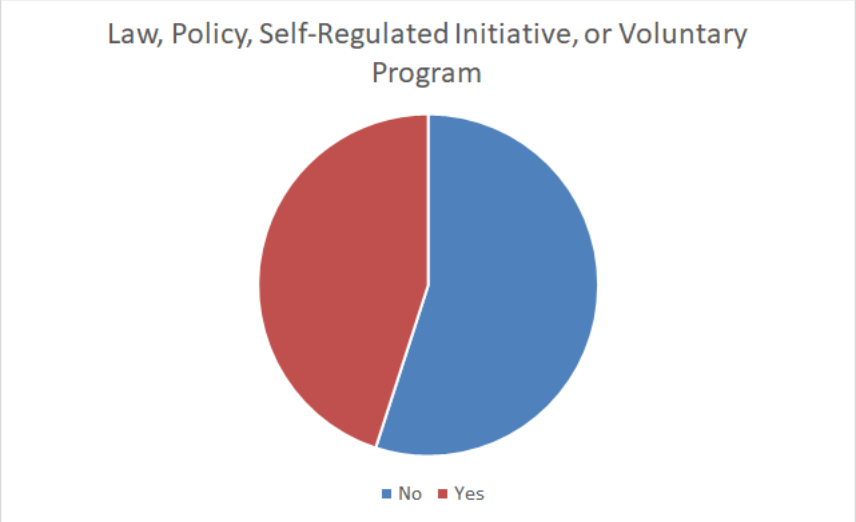
Question: How does your organization collect data on debris that is removed? (Check all that apply)



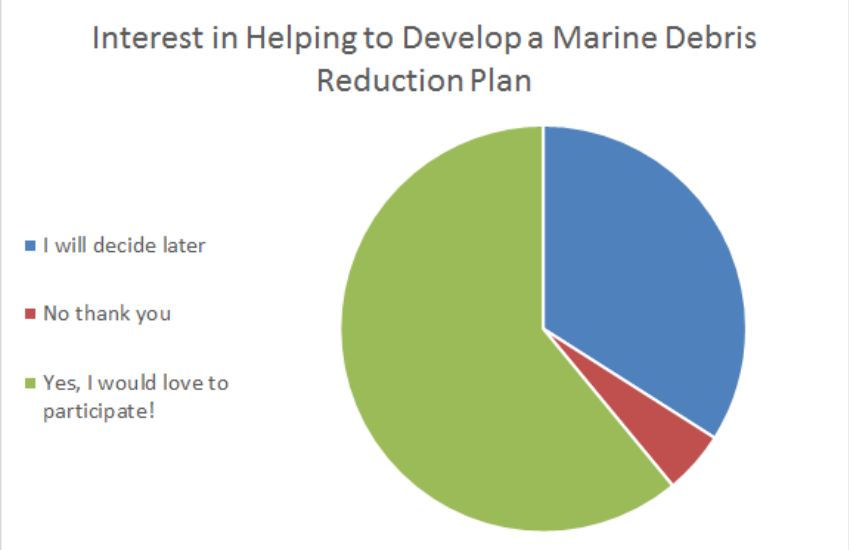
Question: What type(s) of marine debris is your organization focused on managing/addressing? (Check all that apply)



Does your organization administer a law, policy, or voluntary program (e.g. North Carolina Clean Marina Program) or other self-regulated initiative (e.g. Ocean Friendly Establishments) that is directly related to the reduction of marine debris?



Would you or someone from your organization be willing to participate in the development of a marine debris reduction strategy for North Carolina?



What are two strategies and/or actions that would consider to be important in working towards marine debris reduction in North Carolina? ***Note: Answers were binned into broad categories.***

EDUCATION AND OUTREACH (59)	# Respondents
Mandatory education requirement K-12	1
Public and student education, outreach, training, ar	58
LEGAL AND STATE (49)	
Increase lobbying	1
Increase penalties/fines	4
New legislation	1
Derelict vessel removal mechanism/program/law	11
Ban styrofoam; plastic straws and or bags	19
Bottle and/or bag deposit	3
Increase enforcement	9
Pay fisherman to remove derelict gear, state progra	1
WASTE MANAGEMENT AND REDUCTION (30)	
Source control, including stormwater introductions	4
Better waste management (including establishing o	14
Decrease use of single-use plastics	9
Reduce consumer waste	3
REMOVAL AND RESTORATION (14)	
Cleanups, including more; better advertisement an	13
Restoration	1
COLLABORATION AND COORDINATION (9)	
Establish State position dedicated to marine debris	4
Increase collaboration/coordination amongst orgs	5
RESEARCH, TECHNOLOGY, AND DATA (6)	
Develop alternative materials to plastic	4
Standardize data collection and centralize marine d	1
Plastics impacts research	1
FUNDING (5)	
More funding	5