Marine Debris Along the Florida Keys Reef Tract- Mapping, Analysis and Perception Study

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UNIVERSITY OF MIAMI

MARINE DEBRIS ALONG THE FLORIDA KEYS REEF TRACT- MAPPING, ANALYSIS AND PERCEPTION STUDY

By

Mallory E. Watson

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MARINE DEBRIS ALONG THE FLORIDA KEYS REEF TRACT- MAPPING,
ANALYSIS AND PERCEPTION STUDY

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The Florida Keys Reef Tract (FKRT) is a system of benthic habitats from Key Biscayne to the Dry Tortugas. In 2002, the National Oceanic and Atmospheric Administration Southeast Fisheries Science Center’s diver-based Reef Visual Census (RVC) program began collecting information about submerged marine debris along the FKRT. The RVC database identified 1,028 points of marine debris through 2010. Sixty-four percent was classified as “Trap”, 20% was identified as “Fishing”, and the remaining 16% of debris was identified as “Other”. Mapping of the database with Geographic Information Systems (GIS) determined locations of high marine debris observation density in the Upper Keys and Biscayne National Park. Perceptions regarding marine debris, existing regulations and agency involvement of the commercial fishing industry in Southeast Florida were assessed through personal interviews. Results indicate outreach and education efforts should be aimed at recreational fishermen and Miami-Dade commercial fishermen, with targeted removal events in Miami-Dade County incorporating commercial fishermen. These efforts are recommended to minimize derelict fishing gear accumulation and promote monitoring and removal from within the industry. These suggestions aim to build relationships between local agencies and commercial fishing communities to develop more effective marine debris management strategies.
Acknowledgements

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CHAPTER I: Background and Identified Problems

1.1 Identified Problems

1.1.1 Nature of Marine Debris

Marine debris has been identified among the most problematic and persistent marine pollutants. Widely accepted as a detriment to marine ecosystems, it has been studied as a threat to sensitive habitats, fisheries, tourism and human health. Defined as “any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned in the marine environment” (NOAA Marine Debris Program, 2011), almost all anthropogenic products have the potential to become marine debris if not disposed of properly. Marine debris is composed of slow degrading materials (OSPAR Commission, 2008), persisting as floating debris in the water column, resting on the seabed, or washed ashore on beaches (NWPAP, 2009). Its resilience and prevalence in the global marine environment has placed it among the top priorities for the United Nation Environmental Programme (UNEP) over the last fifteen years. Marine debris is an acknowledged problem but its prevalence and scope has only been seen to increase. With nearly 8 million items entering the ocean each day, roughly 6.4 million tons of debris is added to the seas every year. Constantly introduced to the environment at such a rapid rate, marine debris is currently found in all of the world’s oceans (OSPAR Commission, 2008). Marine debris is currently listed as one of nine pollution categories to be acted upon by the under the UNEP Global Programme of Action for Protection of the Marine Environment from Land-Based Activities (Allsopp et. al., 2005).

As the sources of marine debris are a strictly anthropogenic, they can be found in almost everything we use and consume. Synthetic material has become the most
dominant form of solid waste since the late 1960s (Sheavly Consultants, 2006). This has been defined to include non-biodegradable plastic debris and has been known to pose one of the greatest threats to the environment for several decades (Stewart and Yochem, 1990). Plastics contribute to nearly 90% of all marine litter in the ocean and 60% of all marine debris on beaches (U.S. Commission on Ocean Policy, 2004). It has been estimated that there are nearly 64,000 pieces of plastic floating over every square kilometer of ocean today (OSPAR Commission, 2008). Though used by humans for a wide range of important services, plastics have the potential to contribute to the expanding marine debris problem.

Concerns surrounding marine debris stretch far beyond plastics. One-day cleanup events organized through the Ocean Conservancy have been conducted for the last 25 years worldwide, documenting prevalence of cigarettes, glass bottles, rope, and plastic bottle caps, bags, straws, utensils and bottles. Collectively, these items have accounted for 80% of all debris found on beaches and underwater across all one-day events since 1986. Although proven successful and providing important data for research and monitoring, these events are removing marine debris from the environment but not stopping the flow of debris input.

Marine debris is of particular importance due to the imminent ecological, economic and human health threats presented. Over the last quarter century of cleanups, 4,073 organisms have been reported as entangled. Entanglement has been used to describe instances where wildlife is either wrapped in objects and is unable to move or reproduce or accidentally consumes debris mistaking it for food for itself or for its young.
The list of entangling marine debris is topped by fishing line, nets, plastic bags, rope, and crab and lobster traps (Ocean Conservancy/International Coastal Cleanup, 2011).

In a 1997 study, 267 species were cited as being directly impacted by marine debris, including 86% of all sea turtle species and 44% of all seabird species (U.S. Commission on Ocean Policy, 2004). Debris in the ocean can breakdown into small or microscopic particles, resembling the brightly colored food sources of marine fish and seabirds. Plastic bags can also cause accidental ingestion by resembling jellies, the main food source of sea turtles (U.S. Commission on Ocean Policy, 2004). Discarded ropes and line in the water not only entangle marine organisms and habitats, but divers, swimmers and beachgoers as well. Discarded fishing line, rope and even plastic can foul propellers, while larger items may have the ability to puncture hulls (Sheavly Consultants, 2006). Damage to vessels, both commercial and recreational, can be costly or lead to boat stranding events (U.S. Commission on Ocean Policy, 2004).

Plastics, which also provide a serious threat to marine species, can release heavy metals such as cadmium and mercury as it degrades in the water (CEP/UNEP, 2006). Glass, medical industry sharps and metal scraps washing up on shores used by humans can lead to disease transmission, beach closures and heightened perceived risk by the public (Sheavly Consultants, 2006). Personal hygiene debris can enter from poor sewage treatment processes, and may be an indicator of further water contamination (Sheavly and Register, 2007).

1.1.2 Sources of Marine Debris
Sources of marine debris can be categorized as land-based or sea-based, depending on its introduction to the marine environment. Land-based sources, meaning debris that enters the ocean is washed off the land, blown by winds, or intentionally
brought offshore and dumped, contributes nearly 80% of all marine debris (U.S. Commission on Ocean Policy, 2004). Most types of marine debris from land-based activities are domestic, industry and retail wastes (CEP/UNEP, 2006). Land-based sources may stem from beachgoers, marina and port activities, manufactures, transporters, waste disposal and processing facilities, as well as general public littering. These may include both legal and illegal activities (Sheavly Consultants, 2006).

Fishing boats, military and research vessels, recreational boats, cruise and cargo ships, offshore platforms, and supply vessels all contribute to sea-based sources, which accounts for a much smaller percentage of marine debris than its land-based counterpart (Sheavly Consultants, 2006). Sea-based debris includes ship cargo, supplies, waste, equipment and fishing gear (EPA, 2011). While sea-based sources only total 20% of global marine debris (U.S. Commission on Ocean Policy, 2004), it is estimated that nearly 10% of all debris reported in the marine environment is fishing gear (Macfayden et. al., 2009).

1.1.3 Marine Debris along the Florida Keys Reef Tract (FKRT)

The introduction of abandoned, lost and otherwise discarded fishing gear, referred to as “ALDFG” (Matthews, 2009 and Macfayden et. al., 2009), has been identified as is a significant contributor to marine debris (McCoy, 2010). ALDFG is comprised of all nets, lines, traps, and additional recreational and commercial fishing gear which are discarded in the marine environment, both intentionally and unintentionally, directly or indirectly. Most ALDFG remains on the seafloor or entangled in submerged habitats, making it a significantly understudied and ignored problem in many locations (Matthews, 2009). Sensitive coral reefs in regions like Southeast Florida are especially vulnerable to
discarded fishing gear, posing threats of entanglement and abrasion, potentially damaging or killing marine organisms and benthic habitats (Sheavly Consultants, 2006).

Understanding the benthic habitat of the entire Florida Keys Reef Tract (FKRT) in relationship to types of fishing practices that occur there will help to explain the derelict fishing gear problem in the area. Correlating current practices to ALDFG presence and habitat structure will create a better picture of marine debris impacts in the region. Home to the only continental reef systems in the U.S. (Shivlani and Suman, 2000), the FKRT has received attention for its natural resources with boundaries primarily defined by protective limits (Figure 1). Extending from Key Biscayne in the north to the Dry Tortugas in the south the FKRT is almost entirely encompassed by the 2,800 square nautical mile Florida Keys National Marine Sanctuary (FKNMS), covering the waters offshore Biscayne Bay to Dry Tortugas. Biscayne Bay itself is protected under federal jurisdiction in National Park boundaries, or as the Biscayne Bay Aquatic Preserve managed by the state (FDEP 2, 2011).

1.1.4 FKRT Structure and Habitat

The unique structure of the FKRT is composed of extensive mangroves forests, the world’s largest sea grass bed community and the only barrier coral reef structure in the US (Shivlani and Suman, 2000). This combination provides an essential marine habitat supporting commercial and recreational fishing, as well as near-shore recreational activities. Destruction and damage to these sensitive habitats has been acknowledged as a base for cascading impacts throughout the ecosystems (Fourquean, et. al., 2001). Degradation of water quality, coral bleaching, coastal construction and increased boating activity in shallow habitat can lead to negative impacts on this ecologically important region.
The majority of the FKRT benthic habitat is found in shallow water, with the offshore zones of coral reef structures extending 13-15m in depth. The coral reef habitat, designated by structure and composition, can be used to identify specific locations along the FKRT. The fore reef, typically high relief spur and groove topography or low-relief hard bottom, extends from 2-8m depth (Chiappone, et. al, 2005). Sanctuary Preservation Area (SPA) designations within the FKNMS are mostly found in this portion of the reef, given their complexity and ecological importance (Miller, S.L. et. al., 2000). The majority of low relief spur and groove and low relief hard bottom habitats are found just below 8m (Chiappone, et. al, 2005).

Regions of the FKRT can be identified based on geographic structure and reef formation. To the north in Biscayne Bay National Park, a series of offshore linear reefs and inshore patch reefs develops into more frequent patch reef and spur and groove formations moving south into the FKNMS (Miller, M.W. et. al, 2000). The Upper Keys region of the FKNMS is predominantly shallow spur and groove topography, while the Middle Keys are composed of nearshore patch reefs. Further south in the Lower Keys, spur and groove topography picks back up with aggregations of offshore patch reefs (Miller, S.L. et. al., 2000).

Upon designation of the FKNMS in 1990, areas of varying use and protection were proposed throughout the FKRT to balance the commercial, recreation and ecological needs of the sanctuary through zoning. Among uses proposed were SPAs used to protect the most sensitive and intensely used habitat of the FKNMS, typically shallow and small areas of coral reefs (Shivlani and Suman, 2000). Home to species of high commercial and ecological importance, some of which are endangered, damage to this
sensitive habitat by entanglement and abrasion from gear is a critical threat (Uhrin and Matthews, 2007).

1.2 Objectives and Goals

1. The development of a standardized template for recording submerged marine debris during all future Reef Visual Census (RVC) efforts along the FKRT. A specific classification system will be created for debris observed and/or removed that will allow for more streamlined and efficient data entry and can produce a thorough understanding of accumulation and distribution of marine debris.

2. Analyze marine debris trends along the FKRT annually by region, habitat and debris type using RVC data. This analysis will provide mapped data as a resource for agencies and groups conducting removal efforts. Mapping debris trends along the FKRT encompassing both Biscayne Bay and FKNMS will allow for targeted removal efforts in “hotspot” locations.

3. Identify the perception held by commercial fishermen from both Miami-Dade and Monroe Counties regarding marine debris in the FKRT. Understanding the user actions, inputs of debris and relationships between the community and research initiatives will help identify target sources of the derelict commercial fishing gear in the region.
4. Develop recommendations for potential outreach and education platforms which will minimize derelict fishing gear in the FKRT. Through linking RVC observations to the perceptions of commercial fishermen, more effective monitoring, removal, and education of resource users can be explored.
CHAPTER II: GIS Mapping and Analysis of Debris

2.1 Background

2.1.1 NOAA Reef Visual Census

Since 1979, NOAA Fisheries has been conducting a scuba-based Reef Visual Census (RVC) annually along the Florida Keys Reef Tract (FKRT) to study reef fish community structure, patterns, and changes over time. With over 350 survey locations, the RVC program uses a "...habitat-stratified sampling design of the coral reef fish community and associated habitat along the Florida Keys coral reef tract" (NOAA Southeast Fisheries Science Center, 2012). The surveys are conducted in two regions for the reef tract: (1) the Florida Keys from Key Biscayne to Key West; and (2) the Dry Tortugas (Ault and Smith, 2009). The University of Miami, Florida Fish and Wildlife Conservation Commission and the National Park Service have cooperatively participated in these visual surveys, contributing to fish stock assessments and evaluation of marine reserves (NOAA Southeast Fisheries Science Center, 2012).

RVC sampling provides a non-destructive and fishery-independent monitoring method. To collect information on reef fish, a diver will document species within a randomly selected 15m circular plot for 5 minutes. Divers face one direction and list all species within the cylinder’s limits and vertical visibility. Once no new species are observed, divers will rotate through the cylinder. Each survey of one 15m plot is estimated at 15-20 minutes. Abundance and size of reef fish can be collected from these observation periods. Depth, habitat information and location along the reef tract were observed for each plot based on the diver’s observation from the center of the plot. All
divers collecting information with the RVC program are highly experienced divers who
were trained in observation methods and protocols (Ault et al., 2005).

2.1.1.2 Inclusion of Marine Debris Observations
During survey periods starting in 2002, type and amount of observed marine
debris were recorded on those assessments conducted from Biscayne Bay to Key West.
During RVC dives, debris observation was completed in addition to reef fish studies.
RVC data sheets incorporated a “Fishing Gear” category (Figure 2). Divers were able to
write their own description of observed marine debris in the line provided. For each point
of debris located by a diver, a Master Sample Number and ID number were given. The
year, month, day, latitude, longitude and depth were noted at each point. Habitat type,
location along the reef tract and protection designation was specified. Each RVC diver
was assigned a number, which associates each located debris point with a specific diver.
This survey was not explicitly designed as a marine debris reporting or monitoring
program. Types of debris and location were entered as they were observed, but observed
debris was not removed.

2.1.2 GIS and marine debris
Geographical Information Systems (GIS) has been utilized in marine debris
monitoring and removal efforts in regions outside of Southeast Florida. Though most
have dealt with accumulation rates, they had additionally assessed the observation density
of debris located in specific habitats or locations. In 2007, a study led by the University
of Hawaii Joint Institute for Marine and Atmospheric Research (JIMAR) and NOAA
Pacific Islands Fisheries Science Center examined high observation density debris areas
in the Northwestern Hawaiian Islands (NWHI). Using anticipated high observation
density areas and reef characteristics, results were aimed to develop effective monitoring
of locations targeted during large-scale multiagency removals from 1995 through 2005. The NWHI are known to contain large concentrations of abandoned, lost and otherwise derelict fishing gear (ALDFG), specifically nets which drift into shallow water and can become entangled in low wave energy, high-relief reef structures. GIS was utilized to determine high observation density locations in the NWHI. Although a byproduct of the project, debris observation density mapping was recognized to help focus survey and removal efforts as more targeted monitoring and removal began in 2006 (Dameron, et. al., 2007).

Gray’s Reef National Marine Sanctuary (GRNMS), offshore Sapelo Island, GA in the South Atlantic Bight, has focused concerns on marine debris accumulation, specifically ALDFG. To identify spatial distribution and accumulation to be used in designing removal efforts, a project led by NOAA’s Center for Coastal Monitoring and Assessment was implemented to examine the spatial distribution, type and abundance of marine debris. The study by Bauer et al. (2008) focused on debris data to examine the presence of debris in relation with bottom type and physiological features. Broken into categories of fishing gear and non-fishing gear, the study was primarily concerned with recreational fishing activities as most commercial activities have been prohibited in the boundaries of the GRNMS. Spatial distribution of observed debris was reported using GIS to determine areas of high debris observation and the bottom type they are found on. Results were able to correlate distribution of marine debris to bottom type and anthropogenic activities. These results were suggested to be utilized in cleanup events, monitoring and targeted outreach efforts. In this study, recreational fishermen were
suggested as the target audience for outreach and education initiative (Bauer, et. al., 2008).

Most studies incorporating GIS to marine debris observations, similar to Dameron et al. (2007) and Bauer et al. (2008), are direct marine debris surveys. They are designed with the explicit purpose of identifying marine debris presence and using habitat, oceanographic and anthropogenic data to determine driving factors behind debris accumulation or density. Marine debris observations are recorded with that specific goal, so datasets are increasingly reliable and can be combined with additional information on the study area. This provides an opportunity to develop accumulation studies and determine how those factors that influence debris presence. Studies conducted outside the FKRT have used debris observations to develop observation density maps through GIS to develop removal efforts and education initiatives. It has been noted that these mapping projects should be utilized in removals and are a priority for successful program development and long-term monitoring.

2.1.3 Use of GIS in the FKRT

No previous study in the area has used spatial analysis of marine debris presence, absence or habitat impacts for the expanse of the FKRT from Key Biscayne to Key West. Although GIS applications to marine debris have become increasingly prevalent in the last decade, the use of GIS for monitoring and removal has been limited in this region. Previous studies in the FKRT have primarily been concerned with actual location and type of debris present or direct habitat impacts. Most have been focused on portions of the reef tract, like the boundaries of Biscayne National Park or Florida Keys National Marine Sanctuary. Using a known set of debris points, like RVC data, GIS can be applied towards targeted debris removals. These products could be used in designing appropriate
and effective education measures to prevent the further input of submerged marine debris. This has been seen in those previous studies concerned with removal, monitoring and education surrounding submerged marine debris.

With two existing studies in addition to RVC data (Chiappone et al., 2002, 2004, 2005 and Uhrin and Matthews, 2007), there is a robust data source indicating locations of marine debris along the FKRT. If an ancillary debris survey can be successfully applied to targeting debris removals, the inclusion of additional data could lead to a more accurate and effective removal and future monitoring system. This is a critical step in stemming the flow of marine debris in the environment. As indicated by Dameron et al. (2007) and Bauer et al. (2008), understanding locations of high debris density through mapping is essential to focus efforts and to understand the contributing factors influencing the distribution and concentrations of marine debris. The FKRT falls entirely within state and federal management boundaries, containing Essential Fish Habitat (EFH) and sensitive marine organisms. The presence of debris in these locations is of particular concern.

2.1.4 Previous Studies in the FKRT

Results of debris concentration and dominance of debris type is inconsistent among those who have worked in assessing the presence of marine debris along the FKRT. Studies by both Chiappone (2002, 2004, 2005) and Uhrin and Matthews (2007) have been implemented to understand the presence and benthic impacts across the study area. While both are limited to waters in the FKNMS, they express slightly different results. Towed-diver surveys by Uhrin and Matthews (2007), covering 750,000 square meters of benthic habitat, indicated that the largest concentration of trap debris is located in the Middle Keys, with spiny lobster trap debris the most abundant type. These results
are consistent with the conclusion of RVC data that “Trap” debris is the most prevalent, but inconsistent with respect to location of high observation density.

Diver-based surveys by Chiappone et al. (2002, 2004, 2005) spatially identified the density and distribution of marine debris at various locations within the FKNMS, while using results to assess benthic impacts of derelict fishing gear and other identified marine debris. This debris was removed upon sighting. Results suggested both trap and hook and line gear were the most dominant debris, depending on habitat structure. Variations in studies may be attributed to visual assessment methods, project targets and time frame limitations. In working with mobile and accumulating elements like marine debris, values are anticipated to vary over time and survey methods, reiterating the importance of cooperative data collection. RVC data can be a useful tool in targeting the locations of marine debris and understanding the prevalent types of debris along the FKRT. Though done secondary to reef assessment, marine debris observations can be applied to removal efforts in the region. Since submerged debris can only be fully assessed from underwater, these surveys give a better picture of debris that is located offshore and not just those washing up on beaches or in shallow water.

2.1.5 Project Importance Along the FKRT

Results from RVC data have been produced in the form of digital maps which can be updated to reflect current observations. High debris observation density locations will be targeted for future removal efforts. Marine debris observation through RVC surveys have been conducted as a tangential reporting system and do not follow the precise or focused methodologies of other surveys which are designed to enhance monitoring and removal programs. Since the dataset does not include information on oceanographic
conditions, factors such as currents cannot be included to develop an accumulation rate or prediction of debris presence as was done by Dameron et al. (2007).

The project is one of the first applications of GIS to marine debris observations for the entire FKRT and the use of an ancillary debris observation system. Results provide basic mapping of high debris observation density locations along the FKRT and can be used to identify common types of debris and locations to develop removal efforts, which has been the goal in previous marine debris studies utilizing geospatial analysis. It is anticipated that the use of GIS could be applied to the study area in order to develop more comprehensive submerged marine debris projects.

2.2 Materials and Methods

2.2.1 Data source
Access to RVC data has been granted by NOAA Southeast Fisheries Science Center’s Fisheries Assessment, Monitoring and Ecology Program, and served as the primary source of data for this project. A total of 11,578 dives by 66 divers gave 1,132 recorded points of debris from 2002 through 2010. The RVC data has been stored in a Microsoft Access database and has been exported into Microsoft Excel for analysis. Annual RVC observations are added to the database once they are submitted in full through NOAA Southeast Fisheries Science Center. Currently, yearly records are prepared to be added to the marine debris database in the calendar year following surveys. For example, data from 2010 was completed and added to the marine debris database in December 2011.

Software for mapping in GIS (ESRI ArcGIS 10.0) was provided by UM RSMAS. A base map of state of Florida was obtained from the State of Florida (FGDL.org).
Shapefiles for protected and managed areas, including Special Protection Areas, FKNMS boundaries and Biscayne National Park boundaries were obtained from the South Atlantic Fishery Management Council (SAFMC) and Fish and Wildlife Research Institute (FWRI). All marine debris data points were obtained from pre-existing RVC database. All statistical analysis was completed using Microsoft Excel and R statistical software.

2.2.2 Methods
2.2.2.1 Category and Subcategory
Each observation of marine debris was treated as one individual point. If a diver observed more than one item at the same location, information about that location was duplicated so that each debris observation was separated. A classification system was developed to categorize types of debris based on uses and materials. Each debris item has been given one of three classifications. (1)“Trap”, used to define derelict traps and debris from fish traps and spiny lobster, stone and blue crab traps; (2)“Fishing”, which includes hook and line gear, monofilament and nets; or (3) “Other” which defines all identified debris not meeting the specifications of the first two. A subcategory was given to further define each category. Subcategory definitions were more specific than the three debris categories. Assignment of a subcategory was dependent on the terms used to define the observed debris (Table 1). These categories were also used to develop recommended changes to the RVC data sheet (Figure 2). This provides explicit categories for observed marine debris on RVC dives, and will help streamline data entry in the future.

2.2.2.2 Selected Divers
Several entries were incomplete, nondescript or described active traps not qualifying as marine debris. RVC debris data is collected ancillary to reef fish observations, so patterns of marine debris recording are seen to be varied among divers.
In order to maintain consistency in the database, only points qualifying as marine debris under these three categories were retained for mapping and analysis. Although 66 divers contributed to the total data set, not all recorded an equal number of debris points or did so consistently. Sighting frequency was used to determine divers to be included. Over the total 11,578 dives, the debris to dive sighting frequency for all 66 divers is 9.86%, with many divers only recording one categorized item of debris throughout the database. Divers with debris to dive sighting frequencies greater than 10% and with at least two categorized debris data points in the database have been selected for further data analysis and were used for mapping of debris. 20 out of the 66 divers met these criteria.

2.2.2.3 Dive Effort and Debris Presence
Types of debris were defined using the three categories of “Fishing”, “Trap” and “Other”. Only debris observations falling into these categories were included. Debris observations were standardized by total dive effort by the 20 selected divers (4,962 dives over nine years). Observations were compared using a Chi-Squared test using R statistical software to determine differences across types of debris, sightings across years, habitat types and regions debris was observed.

The presence of debris and dive effort was determined for the habitat, Sanctuary Preservation Area (SPA) designation, subregion and reef zone. Habitat included 10 classifications of reef and specified the relief level of the habitat structure. Subregion was used to define the location along the reef tract north to south. The study area was divided into 5 subregions from Key Biscayne to Key West; Biscayne, Upper Keys, Mid-Upper Transition, Middle Keys and Lower Keys. Using SPA designations, 24 categories were created within the study area. All of which are a specific SPA along the reef tract, but include “Unprotected”, which defines all benthic habitat not bounded by SPA
management. Although these areas are still within the FKNMS and Biscayne National Park, they are considered “Unprotected” since they are not under SPA management. Reef zone described the location across the reef tract by “Forereef”, “Inshore”, “Mid Channel”, “Offshore Patch Reef” and “Undetermined”.

To determine sampling effort of divers by habitat, SPA designation, subregion and zone along the study area, debris sightings were standardized by the total number of dives by selected divers (Table 2-5) and the presence of debris was reported as a percentage of total observed debris.

2.2.2.4 GIS Mapping
RVC data stored in Microsoft Excel was imported into ArcGIS 10 ArcMap. XY data of the 1,028 marine debris observations were projected with NAD_1983_HARN. The base map of Florida was also imported and was projected with NAD_1983_HARN. Marine management areas from SAFMC/FWRI was added and projected with NAD_1983_HARN. Biscayne National Park and FKNMS boundaries were selected by attributes from the marine management areas and exported as a new layer. This layer was displayed with the Florida map and all marine debris data to create a map of debris locations from 2002-2010 (Figure 5). Debris type was indicated by symbols representing categories based on the type of debris (Trap, Fishing or Other). This gave a map showing the types of debris along the FKRT (Figure 6).

To identify the regions along the FKRT with the greatest density of marine debris observations from 2002-2010, the point density tool was utilized. A layer was created from a vector grid displaying 1 square mile plots and was overlaid on the study area. The centroid of each grid cell was plotted. A spatial join between 2002-2010 debris points and the centroid of each grid square was completed to create a count of debris
points surrounding each centroid within each square. Using the “COUNT” field in the attribute table of the centroids, point density of debris was expressed as points of debris per square mile. Using all data from 2002-2010, an image of total debris observation density was created (Figure 7). Points from the spatial join were selected individually by year from 2004-2010 (Figures 8-14) to determine concentration of debris by year using the point density tool, identified by the number of points near each grid centroid. The distance from coastal reference points to the highest observation density regions was measured using the measurement tool.

A selection of debris observations from 2002-2010 located within SPAs was made to limit debris displayed to only those falling completely within SPA boundaries (Figure 15). RVC data on habitat surveyed from 2002-2010 was used to develop a habitat map of the study area. Habitat type was assigned to 200x200m grid cells. Applied to the basemap of Florida, this gave a map of habitat types surveyed along the study area (Figure 16).

A selection of debris falling within the “Biscayne” region of the FKRT was created due to the project target of Miami-Dade County and because of visual assessment of high debris observation density locations. This region encompasses locations within the boundaries of Biscayne National Park (BNP). With the debris observation layer, specific habitat types where debris was observed could be determined (Figure 19). The total debris observations from 2002-2010 were also categorized by debris type and plotted on the Florida base map to show the most dominant types of debris in Biscayne Bay and Miami-Dade county (Figure 17).
2.3 Results

2.3.1 Debris Observation Density
For debris observations from 2002-2010, several areas of high marine debris concentration were located within boundaries of the Biscayne National Park. Cumulative debris observation for the nine year data set gave high observation density locations, containing more than 35 observed debris points within one square mile, concentrated in a 50 mile stretch along the FKRT. The region extended 3 miles south of Cape Florida to an area 4.2 miles offshore Key Largo and was approximately 5 miles wide east to west. A second location with high debris observation density was located 3.2 miles southeast of Big Pine Key, 6 miles in diameter (Figure 7).

Debris densities for observations along the FKRT were found for each year from 2004 through 2010 to determine frequency of debris siting annually (Figure 8-14). Annual high siting frequency regions were identified as areas with 9 or more observations per square mile for 2004-2006. In 2004, one region was found 3.3 miles southeast of the channel between North Key Largo and Islandia. Three high siting frequency locations were found in 2005; 1 mile east of Elliott Key, 4.2 miles east of North Key Largo and 4.3 miles east of Key Largo. 2006 had one high siting frequency locations north of Key Largo. These were found 4.6 miles southeast of Cape Florida, 10.8 miles east of Cutler Bay and 4.8 miles north of Elliott Key.

Annual high debris siting regions were identified as areas with 14 or more observations per square mile for 2007-2010. High sighting frequency regions in 2007 were found in three locations. To the north, a high siting frequency cluster was found 10 miles south of Cape Florida and 10.3 miles east of Elliott Key. A second location was
found 5 miles east of Key Largo and a third just south and 3 miles east of Key Largo.

One high siting frequency location was found in 2008 and was 10.4 miles south from the
Miami River entrance and 9.4 miles offshore from Palmetto Bay. Three locations were
found in 2009. To the north, one was located 13.3 miles from the Miami River entrance,
8.4 miles from Palmetto Bay and 3.5 miles North of Elliott Key. A second was located
2.9 miles east of Key Largo and a third was 2.5 miles southeast of Big Pine Key. The
only high siting frequency location in 2010 was 1.8 miles offshore Key Largo.

2.3.2 Types of Debris

Across the entire reef tract, the dominant type of debris was found to be classified
as “Trap”. Including all nine years in the dataset, 64% of identified debris was “Trap”,
20% was “Fishing” and 16% was “Other” types of debris. There was a significant
difference between types of debris for the cumulative data set, $\chi^2(1, N= 1028)= 6.07$, p= 0.01. While there was no significant difference between observed “Fishing” and “Other”
debris, $\chi^2(1, N= 369)= 0.12$, p= 0.73, there were significant differences between “Trap”
and “Fishing”: $\chi^2(1, N= 866)= 4.71$, p= 0.03. and “Trap” and “Other” debris observations
$\chi^2(1, N= 819)= 6.07$, p= 0.01.

“Trap” debris was also dominant in the high observation density regions of BNP,
contributing to 62% of all debris in the Biscayne Bay area. While there was a difference
between the three types of debris found in the Biscayne Bay study area, $\chi^2(2, N= 1027)=
9.77$, p= 0.01, it was dominated by “Trap” gear. (Trap:Fishing $\chi^2(1, N= 277)= 5.15$, p=
0.02; Trap:Other $\chi^2(1, N=261)= 0.156$, p=0.01). With 21% of all debris in this region
defined as “Fishing” and 17% identified as “Other” (Figure 17), there was no significant
difference these types of debris in Biscayne $\chi^2(1, N=126)= 0.16$, p= 0.69.
When broken down by annual observation, “Trap” debris remains dominant. From 2002-2010, annual RVC records give 50-70% identified as “Trap”, 14-36% as “Fishing” and 7-24% as “Other”. The only years in which there weren’t significant differences in the types of debris observed were 2002, $\chi^2(2, N=45)=2.27, p=0.13$, and 2009, $\chi^2(2, N=159)=2.61, p=0.11$. All other years displayed a significant difference in the three types of debris observations\(^1\). There were no significant differences between total debris observations by year, $\chi^2(7, N=1027)=1.98, p=0.96$.

2.3.3 Habitat and Marine Management Areas

The majority of debris located along the study area was found in unprotected water, with only 14% of all debris observations lying within SPA boundaries (Figure 15). Although most observations were found outside of SPAs, these waters are still managed through the FKNMS or BNP where the remaining 85% of debris was recorded, $\chi^2(1, N=875)=10.26, p=0.001$. Of the 14% within SPA boundaries over all nine years, almost 67% was identified as “Trap”, 17% as “Fishing” and 16% as “Other”, $\chi^2(1, N=152)=4.65, p=0.03$. While there were no significant differences “Other” observations, $\chi^2(1, N=161)=1.77, p=0.183$ between unprotected areas and SPAs, “Fishing”, $\chi^2(1, N=208)=6.20, p=0.01$ and “Trap” observations $\chi^2(1, N=658)=6.20, p=0.012$ in unprotected areas were significantly greater than within SPA boundaries.

By study area region, there were no differences in the amount of debris found between Biscayne, Upper Keys, Mid-Upper Transition, Middle Keys and Lower Keys, $\chi^2(3, N=1027)=3.82, p=0.28$. Between Biscayne, Upper Keys and Lower Keys there was no significant difference in dive effort over all nine years, $\chi^2(7, N=4014)=0.193, p=0.96$.

\(^1\) 2003 $\chi^2(2, N=79)=6.25, p=0.01$; 2004 $\chi^2(2, N=80)=9.07, p=0.002$; 2005 $\chi^2(2, N=113)=4.57, p=0.03$; 2006 $\chi^2(2, N=96)=6.33, p=0.01$; 2007 $\chi^2(2, N=194)=6.30, p=0.01$; 2008 $\chi^2(2, N=108)=7.84, p=0.01$; 2010 $\chi^2(2, N=153)=5.46, p=0.02$. 

0.66. However, in 2010 alone the majority of debris was found in Biscayne and the Upper Keys, $\chi^2 (3, N=1027)= 34.39, p= 1.635e-07$.

Of all debris located, 32% was found on isolated-medium relief reef structures while 31% was found on spur and groove low relief habitat, $\chi^2 (7, N= 1027)= 26.57, p= 0.0003$. Debris at the mouth of Biscayne Bay was predominantly found along isolated-low relief habitat along the reef at the mouth of Biscayne Bay, with 44% on both isolated low and medium-relief structures and 28% found on spur and groove low-relief habitats, $\chi^2 (6, N= 332)= 88.32, p< 2.2e-16$ (Figure 19). The mouth of Biscayne Bay and the Biscayne study area to the south has also been identified as a region of high debris observation density in cumulative and annual observation density maps. While there were no differences found between habitat type for the presence of fishing gear across all nine years, $\chi^2 (6, N= 208)= 5.90, p= 0.43$, 23% of trap gear was found on isolated mid-relief habitats, $\chi^2 (6, N= 658)= 13.41, p= 0.04$.

### 2.4 Discussion

#### 2.4.1 Debris Observation Density
Since the entire FKRT is protected and managed through the National Park Service or the National Marine Sanctuary, the presence of debris in this region is particularly disconcerting (Figure 1). Containing EFH and sensitive ecosystems, damage to the FKRT from debris abrasion or entanglement is a primary concern. The highest debris observation density using the cumulative 2002-2010 data was located along the reef at the mouth of Biscayne Bay and extends south within the boundaries of Miami-Dade County for approximately 23 miles. This high observation density stretch continues for approximately 27 miles into Monroe County.
Annual debris observations for 2004, 2005 and 2006 gave high debris densities towards BNP within Miami-Dade County boundaries. Debris in 2004 and 2005 were more concentrated in this area, although 2005 was dispersed throughout the Upper Keys and BNP. 2004 and 2005 were marked by active hurricane seasons. Florida experienced high storm activity in these years, struck by 4 major hurricanes in both years. This storm activity would have the ability to displace or contribute additional debris to the marine environment. The increased presence of debris and wider distribution following storms may be attributed to their impacts. Annual debris observations for 2007, 2008, 2009 and 2010 displayed high observation density within the boundaries of Biscayne National Park and Miami-Dade County. When targeting removal efforts, those areas displaying the highest density of observed marine debris should be targeted. With cumulative data and four years of annual observations showing high observation density regions from Islandia north to Key Biscayne, removal efforts should be targeted to these locations of the FKRT within Miami-Dade County.

2.4.2 Type of Debris
The most dominant type of debris found across the study area over all nine years was identified as “Trap”. This debris classification encompasses all trap debris; trap line, buoys, wooden slats, wire, trap parts and derelict traps. High observation density regions which have been identified for 2002-2010 cumulative data as well as the annual data for 2007, 2008, 2009 and 2010 are all dominated by at least 50% “Trap” debris, most over 60%. The prevalence of trap gear is disconcerting, as its contribution to marine debris has been noted to have impacts on benthic habitats and contribute to ghost fishing. Once the line and buoy are separated from the trap, lines may drift with the currents and entangle marine organisms or, more likely, entangle reef structures. Traps, though typically
weighted with cement, are still capable of drifting large distances with currents along sand or seagrass (Matthews, et. al., 2010). Trap debris is also among the most conspicuous of submerged debris, which could lend to more effective removal by divers. The source of trap materials is linked to commercial fishing practice, since the use of these traps is limited to those with commercial fishing licenses.

Fishing gear, which includes all monofilament line and hook gear, was the second most observed type of debris. Though more difficult to identify on ancillary dive observations, it is equally threatening to the reef system. Monofilament line does not degrade in the marine environment and presents a problem to marine organisms and benthic habitats with the risk of entanglement. Representing 20% of cumulative 2002-2010 data, it accounted for upwards of 37% of debris in a single year. Fishing debris can stem from both commercial and recreational sources. Fishing material like monofilament may be more difficult to identify on monitoring and removal efforts due to its ability to entangle sensitive reef structures. The discrepancy between “Trap” and “Fishing” debris presence has been seen in previous surveys of the FKRT and may be due to variations in observational techniques. Surveys by Chiappone et al. (2002, 2004, 2005) are diver-based assessments explicitly recording marine debris presences and absence. Uhrin and Matthews (2007) and Matthews (2009) used towed-diver surveys, while RVC data was conducted ancillary to reef assessments. Though “Trap” debris is commonly reported submerged debris on diver-based studies, its absolute dominance over “Fishing” gear cannot be asserted given the different methodologies.

“Other” observed types of debris include any objects or materials not encompassed by “Trap” or “Fishing” classifications. Submerged items falling in the
“Other” category can be as damaging and pervasive as trap or fishing materials, composing less than 25% of all debris observations and annual records. These objects, which include anchors, anchor line, chains and undetermined line types have the capacity to drift, entangle and cause abrasion to reef structures. Most are remnants from recreational boating activities and fall outside the scope of commercial fishing practices. Several of these objects are heavy and difficult to remove (anchors, chains, etc.), and may provide problems in removal efforts. Heavier objects may also be more likely to have remained in the location they were last observed if currents and marine organisms were unable to move them over a great distance.

Given that all debris was placed into one of these three categories (Trap, Fishing and Other), future RVC dives should record debris in this format. By utilizing the suggested RVC data sheet (Figure 2), all observations will fit into the current standardization of the marine debris database and GIS mapping. Space is limited on the RVC data sheet and it has been suggested that the created “submerged debris” category be simplified (Figure 3). Although not ideal for the ultimate standardization of this database, it is an improvement over the previous datasheet (Figure 1). Incorporation of a new datasheet (Figure 2 or Figure 3) with three explicit categories will improve entries into the database and may encourage appropriate records of observed debris.

2.4.3 Habitat and Marine Management Areas

By standardizing debris observations with dive effort, the large percentage observed in unprotected waters was consistent with those in SPAs based on the number of total dives conducted. There were significant differences between the amount of debris observed in SPAs and unprotected water, with 85% found in unprotected regions. Although predominantly outside SPAs, the presence of submerged debris in protected
regions should be addressed. All debris recorded, including those considered to be in “Unprotected” locations, falls within waters managed by the National Marine Sanctuary or the National Park Service.

Fishing, boating, diving and other recreational and commercial activities are permitted in the FKNMS and Biscayne National Park. However, there are certain regulations in place to help enhance and protect natural and cultural resources of the FKRT in areas designated as SPAs. These portions of the FKNMS and are typically shallow portions of the reef and contain EFH to be protected. While only 14% of all debris was found within SPA boundaries, it was not expected to find a large amount of debris here, where fishing activities are excluded. While diving, snorkeling and boating are allowed, commercial and recreational fishing is prohibited and limit the opportunity for lost trap or fishing gear to be found here.

Though anticipated to see less “Trap” and “Fishing” defined debris in SPA regions, the gear’s ability to drift large distances makes it more likely to be found in areas where gear is prohibited. The indiscriminant behavior of marine debris with regards to protected waters and man-made management zones makes it increasingly dangerous to marine ecosystems. Most fishermen will deploy traps and fishing gear away from reef structures, and so the aggregation of these types of debris is likely due to drifting rather than deliberate placement.

As expected, more complex reef formations have exhibited the highest concentrations of marine debris. This may be from the increased likelihood of entanglement along the reef structure or the intense commercial and recreational activities along these habitats. Low-lying regions like seagrass and rubble formations are
ecologically important, and although high debris observations are expected here, RVC data targets the reef habitat. It is expected that most observations will be located on high complexity habitats and EFH as opposed to low lying seagrass and rubble formations. Figures 18 and 19 show a comparison between the high observation density region and habitat type in Miami-Dade County. This high debris observation density locations in the northern FKRT sits on isolated low-relief and mid-relief structures as well as spur and groove high-relief and low-relief. The largest expanse of isolated low-relief habitat is located in the exact spot of the largest high-density debris observation.

2.5 Conclusions

2.5.1 Use of GIS

No previous study in the area has used geospatial analysis of marine debris presence, absence or habitat impacts. The benefits which GIS can provide in monitoring and removal have been used sparingly within the FKRT. Using results from RVC data and those explicitly monitoring debris and habitat impacts could both contribute to a map of marine debris presence and threatened habitats. Previous studies have primarily been concerned with actual location and type of debris present or direct habitat impacts. Using GIS with a known set of debris points, like the RVC data, can be applied towards targeted removals and designing appropriate and effective education measures to prevent the further input of submerged marine debris.

2.5.2 Limitations and Applications

When RVC data was collected, no debris was removed. Debris was not weighed, measured or quantified in any way other than recording presence. As it is a presence only data set (not presence-absence) it cannot be compared to locations on the reef tract which
were not observed. The maps produced through GIS provide an image of debris locations over a collective time period. By breaking down the debris siting frequency map into yearly images of debris presence, updated images of debris presence can be provided.

Applying GIS to marine debris monitoring is helpful in understanding the spatial patterns of debris over time. The results of mapping marine debris observation from 2002-2010 using a visual observation method have provided a long-term image of debris presence along the FKRT. While it is limited to the observations of divers at locations specified by RVC protocol, the debris recorded is still present. The presence of marine debris in the FKRT cannot be refuted, especially given the results of RVC data applied to GIS (Figure 5).

The maps produced using RVC data provide a visual representation of debris presence and can be applied to efforts in marine debris monitoring, removal and education. Due to the methodology of RVC sampling, only debris presence was noted. It is reliant on divers to record what they see and to record observations accurately. Human error can contribute to the data set and may create unintentional bias in the database. Larger, more visible debris items may be more likely to be recorded, which include large portions of “Trap” debris, anchors and line, unlike smaller or less visible items like monofilament. As previously noted, studies by Chiappone et al. (2002, 2004, 2005) documented fishing gear as the most prevalent. These were explicit debris surveys conducted in the FKNMS. Urhin and Matthews (2007) concluded that trap gear was most prevalent on diver-towed surveys targeting debris presence. These divers passed over the reef to cover more distance than Chiappone et al. (2002, 2004, 2005). Due to their visual
survey process, they are likely to see a similar pattern as the RVC data; emphasizing larger and more conspicuous items.

RVC observations have created one of the only data sets which accounts for both southern BNP and the FKNMS. This is a pivotal starting point for understanding marine debris across such a large expanse of critical habitat and can provide a better image of debris moving across fluid boundaries. As the project continues and marine debris records become more specific and reliable through RVC dives, it can develop into an accumulation or movement study. However, with the introduction of volunteer and diver-based reporting systems in southeast Florida (FDEP Marine Debris Reporting and Removal Program) observations contributing to datasets are not always part of explicit or designed marine debris surveys. If data from these systems, like the FDEP program, are to be applied towards monitoring and removal mapping the analysis will need to include awareness of the inherent limitations.

With critical habitat lining the FKRT, the presence of these debris items present a serious issue to reef health. Removing submerged debris has become increasingly important, but with such a large study area, selecting where to focus efforts can be challenging. The presence data from RVC observations can be useful in designing these types of removals, especially when the time and effort need to be maximized and produce successful results. As future RVC data is compiled, more specific recording systems can hopefully develop a more reliable and increasingly useful dataset for marine debris monitoring. Previous projects which have indicated the presence and absence of debris or have noted locations of observed debris should consider the application of GIS mapping to target areas of concern and potential mitigation efforts.
2.5.3 Proposed Removals

Proposed removal efforts should be targeted in the Biscayne region in the identified locations of high marine debris observation density. Figures 17, 18 and 19 used the boundaries of Biscayne National Park to further examine the viability of the region as a targeted location for debris removal. Although 2010 (Figure 14) showed moderately dense areas of debris observations within BNP, a high observation density spot was identified at the southern edge of the Park boundary. Aware of the highly mobile nature of marine debris, this could easily be distributed further into the Biscayne region. The cumulative data from 2002-2010 and the annual images of debris observation density suggest that targeting efforts within BNP have the potential to be effective mechanisms of removing damaging debris items. With such a large percentage of debris in the Biscayne region identified as “Trap”, removals may be even more successful since this type of debris tends to be easily spotted by divers.

Though not an exact image of the debris present submerged along the FKRT, it may provide a resource to develop successful removal efforts. By implementing underwater removals in the suggested locations, true values of marine debris presence can be collected. If anticipated amounts of marine debris are present in targeted locations, RVC data may be useful in designing future debris monitoring and removal efforts for Southeast Florida along a habitat in great need of protection from future degradation. The only way to assess the effectiveness of RVC data in marine debris monitoring and removal is to apply it in an actual removal. Images of debris concentration from 2007-2010 show that debris locations are not stagnant, rather they are constantly changing. Each image gives a snapshot of debris presence that year, but has the capability to shift. As the previous four years give high observation density locations within Biscayne
National Park, targeting a removal in this location would be recommended. Efforts should be located in two areas, one north\(^2\) at the mouth of Biscayne Bay and one south\(^3\) towards the boundary between Miami-Dade and Monroe Counties.

Understanding the density of marine debris observations is especially important to mitigating and limiting the problem in Southeast Florida. While there are removal efforts for on-shore and inshore marine debris (International Coastal Cleanup and FWC approved and supported derelict trap gear removals), a deliberate removal targeting known regions of high debris observation density has not been conducted. Using the debris observation density data (Figure 8-14), removals may be targeted toward regions of highest debris concentration either cumulatively or by recent years. These images can also be useful in determining debris movement and accumulation after large storm events, like the 2004 and 2005 hurricane seasons.

The reason for presence and accumulation is still unknown. While dominated by “Trap” debris, especially within Biscayne National Park (Figure 6), the reason for its abandonment in the marine environment or it origin is not clear. Major storm events are commonly attributed to increased marine debris presence with strong currents, wind and wave action. Removals funded by Federal Emergency Management Assistance (FEMA) have been conducted in southeast Florida following large storm events to remove traps and shoreline debris. One such event was carried out in 2000 following the 1999 Atlantic hurricane season which brought Hurricane Irene through Monroe and Miami-Dade

\(^2\) Coordinates for region to be targeted: (-80.135, 25.629), (-80.068, 25.614), (-80.140, 25.535), (-80.074, 25.533)

\(^3\) Coordinates for region to be targeted: (-80.176, 25.439), (-80.119, 25.437), (-80.205, 25.535), (-80.074, 25.533)
Counties. This event, contracting commercial fishermen to participate, removed approximately 11,637 traps and 8,205 buoys with line (Miller, 2007).

It may be difficult to determine if the presence of debris increases with storm activity using RVC data since observations may have been made before, after or even during FEMA clean up events. Although FEMA events are limited to shoreline cleanup, the debris removed could have had the potential to return to deeper water and be seen as submerged debris if it had not been removed. The RVC data can give an indication of what debris distribution looks like after storm activity on annually, but should not be relied upon for exact debris paths or movement. Mapped data should be used to identify patterns or changes in debris observation density around high storm activity years to anticipate removal locations. Using the data from 2004, 2005 and 2006, data indicates removals should focus on the Upper Keys or BNP. Even after two years of high hurricane activity and with the wider distribution in 2005, debris was still largely concentrated in the northern end of the study area. While the debris observation density maps will help with generating more efficient removal efforts, limiting the input will need to start at the source. Just as the GRNMS study (Bauer et al, 2008) determined outreach and education efforts should be focused on recreational fishing to reflect the dominant types of debris observed, the overwhelming presence of “Trap” gear should be used to direct prevention and mitigation efforts in the FKRT. To this end, investigating the perceptions and observations of trap fishermen can help to direct outreach and education efforts to minimize marine debris input, as their materials are the most abundant according to mapping of RVC data.
CHAPTER III: Commercial Fishermen Perceptions of Marine Debris in Southeast Florida

3.1 Background

3.1.1 Commercial Fishing along the FKRT

The Florida Keys alone can be regarded as the most important seafood region in the state of Florida measured in landings, dockside value and numbers of commercial vessels (Chiappone, et. al., 2002). Shown in Table 6, the area encompassed by the FKRT supports fishing of Caribbean spiny lobsters (*Panulirus argus*), stone crabs (*Menippemer cenaria*) and blue crabs (*Callinectes sapidus*). While a total of 4,127,356 pounds of spiny lobster were collected in 2009 between Miami-Dade and Monroe Counties, just under 4 million pounds were landed in Monroe County alone. With a statewide total of 4,246,957 pounds, southeast Florida supported just over 97% of the spiny lobster fishery in the state. Table 7 shows the high economic value of this fishery to the region. At an average dockside value of $3.12 per pound, Miami-Dade and Monroe County spiny lobster fishermen saw roughly $12,877,350 for the 2009 catch. The estimated statewide value of the spiny lobster fishery is $13,261,648 (FWC 2, 2011).

That same year, stone and blue crabs combined across the two counties totaled 737,214 pounds, with Monroe County fishermen contributing 90% of the total crab catch. That year, the state of Florida reported 7,676,955 total pounds of stone and blue crab landed, suggesting a majority is landed outside the FKRT. Although the region is not a top landing site for stone or blue crabs, the fisheries contribute significantly to its economy. Stone crabs, claiming a dockside value of $6.61 per pound, brought in almost $4,487,661 between Miami-Dade and Monroe Counties. While blue crabs fall at prices near $1.21 per pound, the two counties reached a combined estimated value of $70,534 in
These landings are attributed to the county in which the fishery product first comes ashore (FWC, 2011), not necessarily where species are collected.

All three of these species are commercially caught with the use of traps, placing the region at risk for impacts from abandoned, lost or otherwise derelict fishing gear (ALDFG). While there is a global focus on the impacts of fishing gear on the environment, most of these studies are concerned with mobile gear such as trawls and dredges (Barnette, 2001). As spiny lobster and crab fisheries rank as some of the most dominant in the FKRT, trap gear is heavily used. With the ability to deploy large numbers of traps per year, the risk of traps being lost, discarded or abandoned in the marine environment is high. Constructed from wire, line, buoys, wood slats and weights for sinking, derelict traps can be found as fragmented portions or partially intact gear and pose significant risks to the FKRT. Fishermen from trap-reliant fisheries have previously cited a range of incidents which cause them to abandon or lose their gear. Adverse weather, cost of retrieval, gear conflicts, availability of shore-side collection facilities, vandalism or theft and illegal, unregulated and unreported fishing have been listed as some reasons for the introduction of ALDFG in the environment (Matthews, 2009).

It is important to recognize that various commercial and recreational fishing operations in the FKRT utilize hook and line gear and otter trawls in addition to traps. This includes the pink shrimp fishery, which landed over 5 million pounds statewide in 2009 valued at $10,808,630. Although less than 20% of landings were reported from Miami-Dade and Monroe Counties, it is a critical fishery for both. With 251,941 pounds in 2009, it ranks as Miami-Dade County’s largest landing fishery and marked an estimated value of $468,610. It is the third largest fishery by landing pounds in Monroe
County, where the same year brought in 864,465 pounds estimated at $1,607,904 (FWC, 2011). Equally important to the southeast Florida economy is the value of recreational fishing, with over 1 million saltwater licenses sold in 2009 statewide and almost 11 million fishing trips taken in east Florida alone that year (FWC, 2011).

3.1.2 Removal Efforts

The Florida Fish and Wildlife Conservation Commission (FWC) currently supports three programs addressing derelict fishing gear: The Spiny Lobster, Stone Crab and Blue Crab Retrieval Program (Trap Retrieval Program), Derelict Trap and Trap Debris Removal Program, and the Monofilament Recovery & Recycling Program (MRRP). The Trap Retrieval Program operates removals coinciding with 10-day closure periods for the blue crab fishery. Effective since July 1, 2009, these closures occur throughout the state at various times of the year and commercial fishermen are contracted through a competitive-bid process to remove all fishable traps remaining in the water during the closure in an area. During the closure period for the Trap Retrieval Program, all traps remaining in the water are defined as “derelict” to eliminate unauthorized gear removal. Only contracted commercial fishermen are able to participate in these events.

FWC’s Derelict Trap and Trap Debris Removal Program authorizes volunteer removal efforts of derelict trap gear and trap debris for both the closed and open seasons. Since traps are private property, groups must have FWC authorization to remove derelict traps from the water (FWC, 2009). While FWC does not organize these events, it does require all groups applying to coordinate a cleanup adhere to Rule 68B-55, Florida.

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4 FWC defines a trap as “derelict” if it is in the water during a closed season for that fishery; or is a “fishable trap” in the open season lacking more than two of the following: 1) Buoy, 2) Line, 3) Current Commission-issued trap tag, or 4) Identification (for recreational traps) (FWC, 2009).
The application must provide the methods of cleanup, disposal and recording of debris data. At the conclusion of a cleanup event a data summary must be submitted to FWC, including information on each derelict trap removed in the event (FWC, 2011).

The loss of traps in Florida is an accepted occurrence in the commercial fishing industry. The current trap license fee allows for up to 5 traps per fisherman to be lost and recovered without incurring a fine. In 2000, the fee for stone crab trap licenses was set with $25 of each $125 fee to be dedicated to the cover trap retrieval costs. This provides a “waiver” for up to 5 of a fisherman’s lost traps that are recovered. Florida law assigns a $10 per trap fine to the trap owner per each trap retrieved beyond the initial 5 covered by the license fee (FWC, 2007). There is no mechanism to fine fishermen for traps that have lost their identification tags or those which are never recovered. Removal actions are not consistent among all regions in Florida, even with standardized programs conducted through FWC. The Trap Retrieval Program is operated by FWC with only commercial participants, but the events under the Derelict Trap and Trap Debris Removal Program are only authorized (not organized) by FWC. With no mandatory events, involvement from the commercial fishing industry and local community is reliant on education, awareness and incentives to participate.

In Monroe County, removals have been spearheaded by the commercial fishing community in cooperation with current regulations dating back to the mid-1990’s. FWC or DEP has contracted fishermen to remove debris during closure periods or through FEMA hurricane recovery events. Several successful removal efforts from this region

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5 Definitions, Retrieval of Trap Debris, Trap Retrieval Program Funded Pursuant to Section 370.143, Florida Statues, Retrieval of Derelict Traps and Traps Located in Areas Permanently Closed to Trapping, Recovery of Traps in Area of Major Natural Disasters.
have been documented over the last 20 years with partnerships between the commercial industry, research initiatives and state organizations. With a strong organized group of commercial fishermen, ongoing research and vested interests in marine ecosystem, it has led to partnerships to undertake successful removals. This situation is unique to Monroe County, however. To the north in Miami-Dade County, no standard removal or monitoring system exists. Individual efforts by volunteers (approved through FWC), DERM and DEP have generated successful removals, but none as long-standing or inclusive of the commercial sector as in Monroe County.

The MRRP, a statewide effort in public education and monofilament recycling practices, was initiated through a grant from FWC and targets recreational hook and line fisheries. The MRRP encourages users to utilize recycling bins throughout the state to avoid accidental or deliberate disposal of monofilament fishing line in the marine environment (FWC MRRP, 2011). Outdoor and indoor recycling bins are located at tackle shops and fishing sites across Florida, including Miami-Dade and Monroe Counties and can be access through the FWC MRRP website. The voluntary nature of the program makes its success dependent on the awareness and education of users. MRRP is only as effective as the cooperation and willingness of the public. Only single filament fishing line is recyclable, so some types of fishing line will not be applicable to this program even with full public participation (FWC MRRP, 2011).

3.1.3 Outreach and Education

Resource users have some of the most significant impacts on the presence of marine debris, especially derelict fishing gear. While other types of debris are present throughout the water column or onshore, ALDFG is suggested to be the principle type of submerged debris in the FKRT (Chiappone et al., 2002). With its location limiting
accessibility for monitoring and assessment, debris in submerged habitats has also become some of the more understudied marine debris sources (Matthews, 2009). In order to stem the input of marine debris, accurate and appropriate information needs to be provided to the critical group of resource users.

Typically, outreach and education programs related to marine debris have focused on the general public to discourage improper disposal of waste by emphasizing the connection between actions and impacts. A majority of these programs are targeted towards recreational fishing, emphasizing youth and female participation. While an important group to highlight, commercial fishing is equally influential and important to include. The Trap Retrieval Program (FWC) provides an opportunity to connect commercial fishermen with marine debris removal and mitigation, but its effectiveness in minimizing future inputs of ALDFG has not been fully assessed. Assumptions regarding relationships between outreach and commercial fishing are well worth investigating.

Preliminary results from the RVC data suggests an overwhelming majority of all debris located is composed of trap material or fishing gear. This justifies targeting outreach and education efforts toward commercial fishermen, specifically in trap-reliant fisheries whose gear contributes to over 60% of observed debris in the database. In developing these efforts, the perceptions of resource users within Miami-Dade and Monroe Counties have been incorporated. Users included commercial fishing industry representatives, commercial fishermen and members of the scientific community. The approach to marine debris removal differs between the two neighboring counties and so the perceptions of participating fishermen were anticipated to differ as well.
3.2 Materials and Methods

3.2.1 Data Source

All data contributing to the perception study of the project was obtained from in-person and phone interviews. This information was provided by commercial fishermen in Miami-Dade and Monroe Counties and by commercial fishing and FWC representatives. All information included in the perception study was given at the will of participants who were informed of their involvement in the project and notified their identity would be kept anonymous and their responses would be recorded and documented in this report. Data obtained in this study is to be used for recommendations and suggestions for developing a more effective and efficient marine debris removal and monitoring program along the FKRT. This information was intended not to be used to directly alter fishing rights, practices or access for those who participated in the study. All data has been stored on an Olympus voice recorder and transcribed into text files in Word format.

3.2.2 Methods

3.2.2.1 Identifying key study participants within the commercial fishing industry

The first groups approached in the commercial fishing industry were industry and research representatives. Gaining the support and trust of industry leaders and those involved in research initiatives in the region was necessary. The support of these key players was essential in encouraging participants to share their opinions and perspectives. Contact was made with the Executive Director of the Florida Keys Commercial Fishing Association, President of the Organized Fishermen of Florida Marathon Chapter, and those conducting marine debris research through NOAA and FWC. These conversations provided the basic background in the involvement with Monroe County fishermen in marine debris removal and limitations in Miami-Dade County. These conversations, though informal and limited, were essential in introducing the project. While Miami-
Dade County does not have a formal commercial fishing association or organization, contacts with the Department of Environmental Resource Management (DERM) and the owner of a trap yard along the Miami River served as primary contacts for the industry. Informal discussions with these representatives initiated the development of contact lists for the perception study.

### 3.2.2.2 Structured interviews with commercial fishers from Monroe and Miami-Dade counties

Each representative was asked to help develop a list of 5 to 10 commercial fishermen, excluding themselves, who would be willing to participate in an interview discussing their perceptions of marine debris. Interviews were scheduled as in-person meetings and interviews over the phone. Interviews were limited to English-speaking participants in trap fisheries in Miami-Dade and Monroe Counties. A total of 8 industry participants were interviewed; three participants in Miami-Dade were included and five in Monroe. Respondents were briefed on the project’s associations, objectives and goals. They were made aware that conversations would be documented anonymously (i.e. without personal identifiers) and would not be used to directly alter policies regarding fishing rights. Four interviews with Monroe County fishermen and three with Miami-Dade County fishermen were completed. One interview with a Monroe County fishing representative and one interview with a state agency representative were completed. These two individuals were not commercial fishermen, though they work closely with trap fisheries in Southeast Florida.

Interview questions (Appendix A) were intended to be used for each interview, and the conversation was permitted to move at the pace of the respondent. Some interviews diverted from the questions due to participant interest or avoidance. These
discussions targeted dominant issues concerning marine debris in the industry, the most commonly observed types of debris and sources, and perceived impacts of derelict fishing gear or other debris on fishing practices. Secondary topics included the effectiveness of current or previous trap removal programs, limitations in participation and the relationships between fishermen and agencies such as FWC, Sea Grant, DERM and NOAA Fisheries. Interviews were used to determine if commercial fishermen perceived debris as industry-generated or stemming from the general fishing community. The interviews aimed to determine perceptions about the sources of derelict gear and their locations, important information used to determine past and future interests in collaboration and appropriate measures for effective outreach.

Interviews were recorded to maintain accuracy of all comments and discussions. All participants responses were recorded, and reported and summarized without personal identifiers. They were identified only by the county which they were associated and an ID number per respondent was used to track responses. While quotes were used, no names were disclosed in the project. Identity linked to these numbers would not be shared or reported. Each interview was conducted with the same set of thirteen questions. The provided questionnaire for interviews was followed. These questions targeted participant knowledge and awareness of marine debris in southeast Florida, noted impact of marine debris on their industry, involvement in current removal and monitoring efforts, elements driving improper disposal of gear, limitations on removal and willingness to participate in organized removal efforts.

Responses were analyzed by identifying trends in responses. Each respondent was given the same set of questions concerning marine debris presence. These trends were
most associated according to the emotional response. Participants would react to questions with a positive, negative or neutral attitude. Though actual answers were different for each participant, the emotion of the response was used to group results by agreement, dissent or indifference. Not every response was included in analysis as some were incomplete thoughts, avoided the question presented or provided irrelevant information giving no indication of agreement, dissent or indifference. Some participants elaborated on earlier questions as the interview progressed and so it was difficult to match each question up between interviews. Analysis, therefore, is not prepared as a list of responses to one specific question.

Eight total participants were included and all were used in the analysis and all interviews were transcribed in entirety. All fishermen included participated in the spiny lobster fishery, only one indicated participation in the blue crab fishery and four associated with the stone crab fishery. Seven fishermen also mentioned participation in finfish or snapper/grouper fisheries. One fisherman suggested he is involved with “whatever fishery there is”. Selection of participants was not random. Contacts were provided by industry representatives who determined which members of trap fisheries would be best to speak with given language limitations. Industry representatives had full discretion as to who would be included, making the sample small and specific to a few perceptions. These responses can provide an indication of perceptions among fisher populations in Miami-Dade and Monroe Counties, though cannot be considered a true representation. Responses provided include an ID number. Numbers 1, 2, 3, 4 and 5 are Monroe County participants. Numbers 6, 7, and 8 are Miami-Dade County participants.
Participants were not selected at random, but were provided by initial contacts in the industry. With a pre-selected group of individuals and small sample size, no significant trends in the population can be determined. The information gathered is used as an indication of perceptions held in Southeast Florida’s commercial fishing industry but not representative of the entire population.

3.3 Results

3.3.1 Debris Presence
Across both Miami-Dade and Monroe Counties, there was a general acknowledgement that derelict fishing gear is present and needs to be addressed, but isn’t necessarily a problem or problematic to their industry. When asked if derelict fishing gear is a problem or if submerged debris impacts their fishing practices, they would acknowledge its presence but stated it did not negatively impact their fishing activities. None were unable to quantify the amount of debris or derelict fishing material, but reiterated its presence even if it can’t be seen.

I wouldn’t state that it’s a problem. I mean, there’s, there’s stuff that needs to be pulled up- Monroe Participant

I’ve seen old traps, you know, people lose a few here and there. It’s something that needs to be addressed. I don’t know that it’s…how big of a problem it is.- Monroe Participant

…but I know that there’s a lot of traps on the bottom that never get seen, never get picked up. Hurricanes blow them, break ropes, and it’s all just lying on the bottom and there’s traps, just…well, anyways, I can’t prove it, but I just know it.- Miami-Dade Participant

I might see an abandoned trap on the bottom, but more of the traps, by the time I see them, they’re derelicts, they’re all busted up pieces on the bottom of the habitat.- Monroe Participant
Though a general awareness of debris presence exists, the types of debris found in the study area are disputed among commercial fishermen, representatives and researchers. Participants, though acknowledging derelict fishing gear contributes to submerged marine debris, indicate other items as more problematic or common than their gear. There were no direct responses to this question from Miami-Dade participants.

Especially up there [in Biscayne Bay] with all the tourists and stuff. It’s not just the traps and the rope, you got bottles and plastic and all kinds of other junk up there. There’s lots of fishing line wrapped around the main rows and the bottom—Monroe Participant

…we see quite a bit of rope debris that is not associated with the industry. Visitors to the keys are aware of coral problems and so forth. So, it’s a very common practice here to use a black polyethylene line and a common 16-inch cinder block for an anchor. And we see that repeatedly, that even when the concrete boat is entangled, its much simpler, because the investment is only about a dollar and a half, to simply cut the line—Monroe Participant

…I think the number one debris related item on the reef is the monofilament, plastic bags, buoys—Monroe Participant

I’d say monofilament is at the top of that list. The other thing adding to the debris would be illegal habitat, known as casitas—Monroe Participant

3.3.2 Sources

When asked what the most common cause for lost traps, interview respondents cited propeller cut offs and hurricanes as the main reasons. This was frequently associated with the actions of recreational fishermen. Fishermen in Miami-Dade targeted the shrimp fishery as a source of trap loss. No fishermen in Monroe identified another commercial fishing activity as a reason for lost gear.

And you know, [shrimping nets] destroy traps, they destroy everything. That’s the main concern, because those gears, a lot of times you lose 80, 80 traps because those shrimp fishermen, that they’re going to the bottom, the real bottom, destroying the trap and they’re destroying…sometimes we’re losing a lot
of traps because of those and you know, we can’t find them because they’re destroying our traps. – Miami-Dade Participant

Well, mainly sport fishermen…they don’t know what they’re doing. Instead of moving away from the buoy, they come too close to the buoy and that’s how the buoy gets caught in the propeller and then they cut it.- Miami-Dade Participant

Mostly…boats running them over and cutting them off…the only other loss is if we get a hurricane or something bad…- Monroe Participant

It’s like the keys…You got a lot of buoys. I mean, go down there one Saturday and you can see all those crazy people going fishing, going diving. And they, you know they run over those traps, lose lines, and they’re gonna cut a few.- Miami-Dade Participant

I would think that the common loss of a trap would be boat strike, propeller stroke that dissociates the buoy with the trap rope…By far it’s tropical storms and hurricanes that move the traps or break them up to a point that the line would be separated from the trap itself…- Monroe Participant

Oh, the debris is there when the storm comes about and leaves a ton of debris. Because then you lose traps, hundreds of traps, and you can never find them. So, we’re talking about hundreds of traps left in the ocean but the reason we leave them is because we cannot find them…- Miami-Dade Participant

Ignorance and laziness were two of the most commonly reported reasons for general marine debris presence. All participants agreed that the resource users had a hand in the contribution of marine debris; commercial and recreational alike. This was also consistent between counties. It was repeatedly mentioned that limited awareness of all resource users is a big reason for the presence of marine debris. This was seen in Miami-Dade through previous responses to reasons for trap loss, pointing to sport fishermen.

I think it’s basic ignorance of the people that are driving around. If they are smart enough they know what side to stay on the buoys…- Monroe Participant

Laziness, ignorance, people that go out and party and just throw their stuff overboard. For commercial gear, it’s like a said, a lot of people don’t know how to run a boat with the right tide they cut off traps, ropes and buoys, they could eliminate a lot of cutoff if they knew which way the tide was running. So, a lot of it’s ignorance, I’d say.- Monroe Participant
Ignorance. That’s what I think is the largest contributor to marine debris in this area.- Monroe Participant

I think it’s like every community. We have people who are not conscientious. So, those people present a problem to us all.- Monroe Participant

3.3.3 Impact of Debris

Very few participants noted an impact on commercial fishing practices due to debris presence. The greatest impact was the actual loss of gear, but not the presence of submerged debris. Entanglement, prop fouling, impacts on their fishery and ghost fishing were cited as impacts marine debris has on their fishing area. Floating debris, including line, was mentioned as a problem in prop fouling, though not consistently. Most participants in both counties noted that though debris does not directly help or harm their fishing, its presence is not always positive. Participants noted that lobster traps, made from wood, will degrade within two years and suggested they have a minimal environmental impact. Some mentioned they actually have a positive impact by creating habitat as they degrade.

No, I don’t think [derelict gear is a problem]. It takes about two years. Yeah, two years. Suppose I lose a trap, in two years, that trap is gone.- Miami-Dade Participant

The only thing that’s not gonna disappear is the cement that you put on those traps and after a year, the cement is gonna stay on the bottom of the ocean. But, uh, you got a lot of cement there in the ocean it helps the fish in the area…It’s like a fishery. You go after 4 or 6 years you’re gonna have a lot of fish cause they go out on the cement things.- Monroe Participant

It would present a problem for us if there’s entanglement with the coral, we have additional trap loss and it’s an expense we just can’t sustain on a long-term basis.- Monroe Participant

We realize the importance of getting derelict traps out of the water, because they’re going to continue to catch product and that could have a significant impact on a population. And we don’t want that to occur.- Monroe Participant
3.3.4 Location of Debris

While participants largely understood submerged marine debris is present in their environment, the location or the amount of debris was not agreed upon. Miami-Dade participants were not as confident that trap gear would be found in Biscayne Bay or along the reef. Monroe County responses indicated there is debris on the reef, though insistent it is not from intentional disposal along the reefs. From both counties, general consensus is that traps are not placed on or near the reefs or in protected areas. While Miami-Dade participants tended to refute its presence in non-fished areas, Monroe participant tended to acknowledge the potential for its presence in these locations.

You know, there’s a national park here in Biscayne Bay. We got a large park here in this Bay that’s an official sanctuary for lobster and I don’t think anybody can fish there, you know…the sanctuary’s right there, so all that Bay should be heavily protected. So I don’t know how, what kinda debris you’re getting out there.- Miami-Dade Participant

…normally, you would not find [trap debris] in open areas because it’s buoyant, especially if the buoy is attached to it, it’s going to end up in the mangroves or along the shoreline somewhere. Or, you might find, depending on the time of tide, you might find concentrations of it in weed lines and debris lines further offshore.- Monroe Participant

Placing traps on coral is actually non-productive. You wanna be away from them. These lobster vacate these areas at night, they get out there on the move and that’s how they get into the traps.- Monroe Participant

3.3.5 Role of Commercial Fishermen

3.3.5.1 Personal Actions

All fishermen interviewed had been involved in the industry for 30 years or more. All have been fishing out of the same location their entire fishing career. They are all associated with a specific fish house in the Keys or along the Miami River. Participants were asked if it is more efficient for them to search for lost traps or to purchase new materials. All participants stated removal was their primary option. Motivation for
removal is mostly financial based, though several discussed the environmental benefits to removing the traps.

We go look for it as hard as we can…a lot of times we try to mark it with a depth finder. If the water’s muddy we’ll throw grapple hooks trying to get it back, we do all kinds of different methods. They’re expensive.- Monroe Participant

We bring our stuff home every day and put them in containers and I think a lot of people don’t practice that- Monroe Participant

I fish in shallow water so I try to flag it…I call it my second mate on the boat, I have a grapple hook lined up and when it’s slack tide or clear water I always try to run around where I think I’ve lost gear and try to find whatever I’ve lost so I can get it off the bottom.- Monroe Participant

…I think professional fishermen go out and get all their stuff back…because they do that, they stay in business longer. Where the people who leave their gear out there and things like that, they are not looking, they don’t have a substantial, long term outlook.- Monroe Participant

I always go after my gear. I only lose…I lose less than two percent of my gear because if it’s cut off I’ll throw the grapple hook for it. My electronics is sophisticated enough I can see it on the bottom and I’ll work as long as I can to get it back. Because, like the lobster traps I build cost $30 a piece, they’re all stainless steel, and if I lose…I usually catch 70 or 80 dollars of product out of every trap. So, if I get that trap back, I can keep fishing it and not only do I save the cost of the trap, but I get the yield that that trap would have produced.- Monroe Participant

I’ve noticed a significant increase in concern about it, of course, I think to some extent it’s always been present because losing gear is extremely costly to fishermen. That $40 per trap on average, the numbers can add up relatively quickly…we need to protect corals and seagrasses and things that harvest, that sustain and protect the animals that we harvest. So, it’s a high priority for us.- Monroe Participant

100% of the times when I lose gear, I try to look for it. I do not stop until I can find it. Or, if it’s not there, there’s nothing I can do about it. So, I look for it.- Miami-Dade Participant

Well, sometimes you gotta bring it out of the water, you know you don’t wanna pollute your area where you’re fishing. You know, you wanna…if you have parts close to the reef and you lose that trap, you know, I don’t think it would do any
harm, but it’s a waste thing. You can’t throw nothing, can’t bring things in the ocean, it’s bad…- Miami-Dade Participant

It all depends. If I’m going in early I just leave it there, but, if I have time, I take it out and put it back in the garbage. I try to take care of the ocean.- Miami-Dade Participant

3.3.5.2 Removal Awareness and Involvement

All participants cited events in which they will remove floating debris while on the water and what might limit them from actively removing on their own time. All Monroe County participants had been involved with or had heard of Sea Grant, FWC and removal efforts and were well versed in the laws surrounding derelict traps in Florida. Motivation for participating in removals was primarily the need to clean up their reefs, although financial incentives were mentioned as a large benefit. Miami-Dade participants had not heard of sanctioned removals during the closure period in the summer. None from Miami-Dade had participated in an approved removal. Participants in Miami-Dade were interested in removing gear, but were concerned with time being taken away from their fishing. These comments are addressed with respect to future removals, since they have not been involved with one to date.

…it’s nice making a little bit of money that time of year, but it’s not all about the money. It’s, you know, we used to do them for free. We did them for free for years. But it’s also good, you know, we can used a little work that time of year…And it’s also cleaning up, you know, the stuff that needs to be cleaned up.- Monroe Participant

Just being a part of our commercial fisherman’s association and the organization and they also pay us. It’s good money in the summer.- Monroe Participant

What motivates me to participate in them? It needs to be done. We need to clean up after ourselves.- Monroe Participant

Oh, well it’s our fishery, it’s our resource, it’s our habitat, we want a healthy habitat and a healthy resource and a lot of that is spawning areas and stuff and
entanglements are a problem whether it’s endangered species… so anything we can do to help clean that stuff up, we’re helping to clean up our backyard.- Monroe Participant

…some folks have questioned the fact that what you’re doing is just simply because you’re getting paid. Well you have to put it in this perspective. The debris that we’re recovering, almost all of it is storm or hurricane related and this is a FEMA assistance program and so why shouldn’t the people that were impacted and have lost revenue, lost their traps, so forth, why shouldn’t they be the ones that we would select to do that? - Monroe Participant

3.3.6 Agency Involvement and Regulations
Miami-Dade fishermen had heard of the FWC, but had not heard of Sea Grant or other local agencies. They were less clear on the laws surrounding derelict traps and unsure of protocol surrounding removals and disposal. State regulations were reported as a reason traps are left in the water in Miami-Dade, though not in Monroe. Miami-Dade participants gave inaccurate or inflated fines, punishment or non-specific regulations surrounding the removal of traps where they fish. Participants expressed a desire to keep the reefs and fishing habitat clear of debris, though pointed to the current regulations as both a hindrance and positive influence where they work.

…well I’ve heard about the Department of Environmental Management, but I don’t know that much about it.- Miami-Dade Participant

Usually every time I see a trap from any of my friends left, I pick it up and bring it to them. But there is a law now, that you cannot pull a trap of anybody else’s into your boat. So, that’s why I leave a lot of traps out there that I cannot bring into my boat and bring it to my friends… Because of this law, I cannot touch those traps, so they are left out in the ocean… - Miami-Dade Participant

I’d say 90% of the fishermen would love to remove the traps they see in the water. But right now, they are not allowed to. - Miami-Dade Participant

…there’s a law out there because a lot of fishermen are doing that right now. Because they find the traps out there, the Wildlife Commission, if they find it, you know they go diving, if they find one of your traps, you’re gonna get a ticket… They gonna fine you $200 right now, so a lot of fishermen are bringing
the traps in and throwing them in the waste... It’s not a problem for me, it’s good for me because I don’t wanna leave anything out there.- Miami-Dade Participant

No, [removing someone else’s traps is] illegal. You can get 5 years... If I found a fisherman’s trap out there that is lost, I can’t bring it in on my boat, because the Wildlife Commission won’t let you...- Miami-Dade Participant

But I can tell you, all the fishermen are getting those gears right now after last year, no, starting two years back, getting all the gears in. You know why? Cause the WF from Tallahassee, they said you...you got a number on your cement and if you got a gear that is left in the ocean and you didn’t pick it up, they give you a $100 in your face. I’ve seen fishermen getting, they’ve been putting $300-400 worth of tickets...I think it’s a good thing because, uh, I don’t think anybody should leave any traps out there in the ocean.- Miami-Dade Participant

...you can bring it in and say “I found it”, and they’re gonna say “no, you lost it”, you know, it’s our word against them.- Miami-Dade Participant

You know, I do what I can, and I, but I can’t because if they get me they’re gonna say I was stealing the traps, but I have to observe the law that they have.- Miami-Dade Participant

Miami-Dade participants were more wary of involvement with agencies. One discussion with a participant from Miami-Dade was told the project was working with Sea Grant, described as “an agency in Miami”. The response drastically altered the discussion. Participants in Monroe, though supportive of involvement, were quick to remind that agencies or government projects need to be careful of fulfilling promises made to the commercial fishing community.

You’re working for them, or the University of Miami?...Are you working for them?- Miami-Dade Participant

It’s a good idea if it’s done properly. But, when the government tells you they’re gonna do one thing and does another...no. Hey, that ain’t no good.- Monroe Participant
Monroe participants were, in general, supportive of the actions local agencies had taken in their fishing area. All had heard of or had contact with FWC, though some had not heard of Sea Grant. Those who had were immensely supportive of their actions and involvement. There was no request from participants for less interaction with agencies like NOAA, DERM, FWC or Sea Grant. If anything, they requested more information from them and suggested increased cooperation.

We all try to work together real well... If they wanna be involved, that’s great. You know, if they don’t want me involved, we still need to go do the work. If they wanna be involved, that’s great too. - Monroe Participant

FWC we have a pretty good relationship with them… I’m happy to see them out on the water I like the contact with them. I would rather have them here with a stronger presence. You know the people that are doing right.- Monroe Participant

Well, our local Sea Grant person does a fantastic job…he’s a major asset for us. One time I was at the Gulf of Mexico Fisheries Management Council and Doug was a major asset for me, cause I did my homework and any time I had a question, Doug was there to answer it for me. It’s a wonderful thing.- Monroe Participant

3.3.7 Trap Disposal

Participants were asked about the current regulations surrounding trap removal and disposal. Questions focused on the effectiveness of current removal practices to dispose of any and all derelict gear removed during closure periods. All respondent fishermen, even those who understood and wanted to comply with regulations, suggested that reselling, reusing or redistributing derelict gear could benefit the industry. All were primarily concerned with abiding by current regulations and stated they would not act against them for their own benefit.
Yeah, it’s a complete waste of money, I mean on that perspective. - Monroe Participant (In response to being obligated to throw away revered gear during the closure period)

You know, when you do the trap retrievals, when, when traps are whole and in good shape, the plastic crab traps in the water, it’d be nice to see those go to a good use. You know, it’d be good if the state could take those crab traps, and resell them, you know? So, rather than the fishermen paying money to dispose of them, why can’t the state take them? Say a new crab trap costs $20. Say they’re in great shape, you can sell them to the fishermen for $10 apiece. I mean, that way it gets money into that cleanup thing, but also keeps the plastic crab traps outta the garbage. You know, I know there’s legal issues because it’s people’s numbers on the trap, but why can’t you notify the people’s numbers the trap belongs to and give them the right to buy their trap back at $10 apiece and if they don’t want to buy them, they can be sold to somebody else. So I mean, why can’t there be a program like that? - Monroe Participant

(Do you think it would be more useful if fishermen were able to get the traps back?)
Well, of course. Of course. – Miami-Dade Participant

(Would it be better if you collected a trap and you could give it back to somebody?)
Yeah, sure, it’s better for me because I can bring my friend’s traps in for them, because sometimes they’re new, and they boats cut them. – Miami-Dade Participant

We’ve had a number of people that actually wanted to buy the buoys that were recovered, because you can string 3 or 4 of them together and as tourists come down the overseas highway they’re more than willing to put up a fair amount of dead presidents to go home with a string of lobster buoys and I can tell you this, the more abused and beat up they are, the more popular… We could have taken 6 or 8,000 buoys and I guarantee you we could have sold every single one of those buoys just pennies a piece or nickel a piece or ten cents apiece, times 6-8,000, now we’re starting to pocket a few bucks. What would you do with that money? Well, you could put it into research to study the problems, you could do additional cleanups. - Monroe Participant

While fishermen in Miami-Dade and Monroe are not directly responsible for covering the costs of disposal, trap yards do pay the hauling costs for the dumpsters on their property. Fishermen are responsible for the associated costs of retrieval, including mates and fuel, unless part of an organized removal funded through a grant or annual
closure period removals. Materials used in removals are their own property, such as vessels, winches and grapple hooks used to remove gear.

3.3.8 Interest in Removal Involvement
Participants were asked about their interest in participating in a hypothetical removal event in the summer of 2012. They were first asked about their interest in participating in a removal in the proposed removal area within Biscayne Bay. They were told about potential use of grant funds to cover their costs after their initial response. No participants stated financial incentives were a requirement to their involvement. All participants stated time and location as the biggest factors determining their ability to participate in a removal event. This was consistent between Miami-Dade and Monroe Counties. Miami-Dade participants initially claimed they could not participate due to the law on removing derelict traps. Once it was explained that we were permitted to remove them during the closure period through FWC, they responded positively.

That’s kind of a long ways for me to go. And that’s an area that I don’t know, I don’t know what I’m getting myself into there. I don’t really go up there to use it. But, if there was a way I could help with a little bit of knowledge and it wasn’t during the time that I had to be working down here, then I would, yeah.- Monroe Participant

I take it would be in the summertime when we’re not fishing? It would be something that we could be a part of and give back and help clean up…and a lot of that stuff, the debris, is from us, and then there’s a lot of trash that gets picked up also. But, especially if there was a grant and we would be making money in the summer. Yeah, yeah I would help out - Monroe Participant

Well, what might keep me away from it, is my boat burns a lot of fuel. I’ve got a 1,000 horsepower engine and when I run it’s usually sitting there at 32 gallons an hour. And for me to get from here to there and back…it would be a 150 gallons. That would be the only thing that would ever really stop me from doing it. - Monroe Participant
Oh yeah, you could contact me anytime you want. I would gladly talk to my friends to see what they would think about that.— Miami-Dade Participant

Well, the only thing is the debris. The only way to get that gear is to go diving…- Miami-Dade Participant

If…I got 3,000 traps, you know and it’s gonna be very hard for me to be participating in that. I mean, I won’t have the time.- Miami-Dade Participant

3.4 Discussion

3.4.1 Variations in Miami-Dade and Monroe Perceptions

Miami-Dade does not have any commercial fishing association or organization, while Monroe has the FKCFA and a chapter of the Organized Fishermen of Florida. This lack of organization among fishermen was expected to lead to differing responses regarding relationships with agencies, interest in removal and perceptions of debris presence. Not having a collective interest or responsible group representing their interests, Miami-Dade fishermen are largely independent of one another with limited communication outside their trap yard or specific fishery. There seems to be more tension between different fisheries than between those in Monroe. Rather than speaking for the collective industry, conversations with Miami-Dade participants were more individualistic or focused on “friends” rather than the entire fishing industry.

The social dynamics of these two groups required different sampling methods. A lack of associated group prohibited in-person meetings in Miami-Dade, while Monroe meetings were done at the docks with the presence of a representative from the FKCFA. This presence may have influenced responses, with the representative identifying interviewees and scheduling their interviews. In addition, the association representative was present during all interviews. Miami-Dade interviews were conducted over the phone without any outside influence present. The presence or absence of an associated group in
the commercial fishing industry may have impacted both groups to varying degrees, but this would have occurred in any type of one on one interview or focus group depending on those present.

The structure of the commercial fishing community in both seemed to influence responses, either creating a group informed and involved with regulatory decisions or individuals who are left to understand these laws on an individual basis with little or no input. The biggest difference in perceptions regarding marine debris between the two counties was an understanding of the regulations surrounding derelict trap gear. Miami-Dade participants were less familiar with regulations and initiatives dealing with marine debris and derelict trap removal. With no formal removal program engaging commercial fishermen in the Miami-Dade, this may explain some incorrect responses. Participants from both locations acknowledged the presence of debris, including their own gear. Both were interested in potential removal efforts with the primary reasoning being to benefit their industry’s sustainability and fishery and habitat health. Time, financial constraints and distance to travel were all limiting factors for both, but no participant asked about financial incentives when discussing potential removals.

Most participants in Monroe emphasized the issue with debris unrelated to their industry, while Miami-Dade participants mostly identified their gear and commercial fishing activities as a source of the debris. However, both groups of participants identified a major source as ignorance, laziness and lack of understanding from recreational users. Miami-Dade participants suggested debris was a result of activities in other fisheries, specifically shrimp fisheries. There is a general acknowledgement that debris is a problem, that commercial fishing contributes to it but recreational activities
share a portion of the blame. Across all participants, it was evident that derelict fishing gear is not present due to intentional deposition or lack of attention from the industry. It was described as a potential and accepted loss each fisherman may encounter.

3.4.2 Impacts of Debris
Commercial fishermen interviewed do not treat debris as a passive problem, but view it as a present issue they do not have much control over. Both counties indicated issues associated with derelict gear though did not suggest it caused serious problems with their fishing activities directly. Since most derelict fishing gear is submerged, it would not be expected that it would generate a direct impact. Lobster traps, which are built from wood slats and concrete, seem to generate the smallest environmental concern. Most fishermen commented that these traps will disintegrate within two years, although they did not elaborate on the potential impact these traps could have in those two years.

Initially, the interview responses suggest trends opposite of what the RVC data has mapped out. There are concentrations of debris located less than 5 miles offshore and it’s dominantly trap gear. It would be expected that fishermen would be seeing this debris and with the amount of trap line present, it seems this would be frequently noted. However, all debris is observed when submerged 3-20 feet. They would likely not be seeing the debris noted in the RVC data. This also suggests that objects like line are entangled in the reef enough that they are completely submerged in these areas.

RVC sampling is also located along the reef. Most fishermen were citing instances in which traps are washed up in storms and are found in mangroves but they were not able to quantify the amount or damage done on the reefs. This can be explained by basic fishing practices; no trap fisherman is setting traps on the reef. They are aware
that it is present in these locations, but were not able to speak to locations or specific amounts found in these areas. Most fishermen respondents were familiar with shoreline debris and its impacts, but submerged debris, though a problem recognized by the community, is not as visible and present issue to deal with.

The biggest impact derelict gear has on commercial fishing as identified by the interviewees is the actual loss of traps. Each trap costs roughly $40. The value of the trap increases if there is product inside. When a trap is lost, the total cost of the trap is lost. Economically, it is better for a fisherman to use their time and fuel to search for their lost traps than it is to leave it and purchase or build a new trap. Understanding this, it’s clear that the majority of commercial fishermen in Miami-Dade and Monroe Counties will make every effort to recover lost traps. While there is a general awareness across the region that derelict gear can pose an environmental problem, it is equated with economic loss for the industry. It is a great example of a group identifying financial gain with environmental responsibility as a feedback system.

3.4.3 Effectiveness of Monitoring and Removal Programs
Although FWC authorized removals during the closure period can occur in Miami-Dade waters at the same time as Monroe, no such initiative has been repeatedly taken in Miami-Dade. Commercial fishermen in Monroe County were well aware of and knowledgeable in FWC regulations and removal initiatives. The presence of an association has a large influence on this. FKCFA and OFF have partnered with FWC in providing commercial fishermen for removals during the closure period. According to association representatives, there is a waiting list for interested fishermen to participate.
Interest is high and all participants in this project responded to the removal events with positive enthusiasm. They are a welcome part of commercial fishing in Monroe County.

The biggest concern from all respondent fishermen, but especially those who have participated in removals, are the regulations requiring all removed gear to be disposed of. Only in the event of a natural disaster can a fisherman reclaim their lost traps from a removal program\(^6\), assuming the identification number is still intact and visible. In all other circumstances, removal of traps during the closure period must be disposed of upon retrieval at shore. While most fishermen discussed that they will always take every effort to repair and reuse their trap materials when recovered, these lost traps cannot be reclaimed. Rather than resell the traps or place the materials back into use, they become waste. Commercial fishermen interviewed frequently expressed a desire to reclaim these traps or have a state-run buyback program. Not only did they view this as more cost efficient for their industry, but suggested profits from the buyback be placed into future removals or marine debris work. They also noted the disposing of these materials creates more waste and forces more resources to be used in creating new traps.

Commercial fishermen in Monroe, who had experience working with the FWC removals in the past were able to give a number of suggestions and scenarios in which this would be beneficial for them and would be more environmentally responsible. Although not able to speak to such detail, Miami-Dade respondent fishermen were equally interested in the ability to recover lost traps. There, it was more of a community-serving focus. The basic claim was that if you remove and throw away traps, some of

\(^6\) 68B-55.003 Trap Retrieval Program Funded Pursuant to Sections 379.368 and 379.2424, F.S. (4) Trap owners affected by a disaster, pursuant to Section 379.368(3), F.S., will be allowed ten calendar days after notification to claim traps from a Commission authorized storage area. Unclaimed traps will be properly disabled and disposed of as trap debris.
their friends and fellow commercial fishermen were losing brand new traps that had been cut off in a storm or by a propeller strike. They understood the law was in place, but it seemed to work against them even if they respect its presence.

Informal discussions with commercial fishers from both counties have reiterated the point that time is money in the commercial fishing industry. Their top priority is financial gain and any projects or initiatives that may stand in the way will be met with resistance. Any project has to be developed to be worth their while financially and work around their schedule. Lack of participation in sponsored removal events should not be perceived as a lack of interest or due to limited incentives. Most fishermen approached are willing to participate with the only limitations being timing and losses they may incur.

3.4.4 Outreach and Education

During an interview with one of the participants, they were asked how we could solve the issue of marine debris in Southeast Florida. Their response was simple, but reinforced the point.

I think education’s one of the most important things you can do besides picking it up. - Monroe Participant

While participants believed the presence of marine debris and derelict gear was an issue at varying degrees, they all acknowledged the sources of debris come from general ignorance, lack of awareness and laziness. It is a problem stemming from a series of behaviors. No fishermen claimed that they were free of blame, either. All admitted that their gear is a source of debris and is present in the marine environment where it doesn’t belong. At some point, the loss of gear is an accepted consequence of commercial
fishing. FWC regulations fine fishermen at $5 per retrieved trap in removals, but waive the first 5 traps recovered. It is anticipated that fishermen will accidentally lose up to 5 traps or have them cut by storms or propeller strikes. Still, the industry does not accept this lightly.

Commercial fishermen in Monroe County have, for the most part, been educated on the impacts, rules, regulations and consequences of marine debris and derelict fishing gear. Much of this can be attributed to their associations which have worked to link them to local agencies and involve them in decisions made that will impact their fishery. There was an overwhelming desire to be involved with any activity that would be conducted in their fishing area and in molding decisions that could alter their industry practices. No participant from Monroe County was wary of or deterred by the presence of local and state agencies in their water. Most suggested increased contact with and information from them regarding marine debris. They are willing to be educated and are willing to share their information with these groups.

The lack of associated groups in Miami-Dade has, in some ways, hindered their access to these same agencies that are making decisions that will also impact their fisheries. While they have equally important information that can be utilized in decision making, there is no representative of the collective group. While they are able to focus their time strictly in their fishing efforts without outside commitments to the commercial fishing community, they do not have the established connection to the local agencies that are willing to support them in many ways. There seemed to be a gap in the Miami-Dade perception of agency work, where Monroe County participants have developed perceptions based on actual involvement.
Both groups seemed to agree that marine debris is an issue stemming from a lack of knowledge. This may be recreational or fellow commercial users, but the consensus points to minimal awareness and education surrounding the sources and impacts of marine debris. Most claimed ignorance or laziness as the sources, some suggested the way to fix the marine debris problem in southeast Florida is to improve education. Participants were well aware of what causes marine debris, had a general idea of impacts and recognized it as an issue that could negatively affect their fisheries. Although not experts in the subject, their awareness of the problem is sufficient enough to limit the input of debris to the extent they are capable. A bigger gap for commercial fishermen is in the education on regulations surrounding derelict fishing gear; their rights, penalties and potential benefits in mitigation efforts.

3.4.5 Agency Relationships and Involvement

While Monroe County participants expressed a positive relationship with local agencies and through their commercial fishing associations, this has not always been the case. Perceptions of commercial fishermen in Monroe County gathered through previous studies (Suman et. al., 1999; Lipuma and Meltzoff, 2008) indicate this has been a developing process and somewhat recent in its formation. Commercial fishing is autonomous by design and makes the formation of large associations willing to work towards one cause difficult (Lipuma and Meltzoff, 2008).

In Monroe County, where agency presence is strong and visible, participants associated positive results from their involvement. This is specific to participants who are involved in the FKCA and OFF. These organizations ensure and encourage contact between commercial fishermen and agencies like FWC and Sea Grant to both improve
public opinions and ensure their voice is heard in decisions made regarding their industry. Several participants from Monroe had been to regional fishery council meetings, provided opinions during public comment periods, or had sat on advisory committees and fisheries council boards for the South Atlantic.

These participants encouraged the presence of agencies in their industry. Their main focus is the protection of their industry and livelihoods. Relationships with these agencies have been developed on the basis that they are acting in their best interest, although it is understood that not all actions will be met with full support. This positive relationship could likely be credited to the strong associated structure of Monroe County commercial fishing. This region utilizes research, education and state agencies to promote their objectives. While there are still several fishermen who do not participate in the county’s associations, it should be noted that those involved had a positive relationship with agencies that work directly with their industry.

Miami-Dade, lacking a structured organization or individual representatives of their industry, has a more negative or neutral opinion of local and state agencies. While some admitted to not knowing much about them, there was a clear resistance to being involved with a project which was associated with anything labeled as an “agency”. Although the actions of the FWC in establishing stricter policies regarding derelict fishing gear were seen as a positive influence on their fishing practices, it was also misunderstood. Rather than a communal environment in which the fishing industry is collectively working to protect its rights, it has a much more individualistic feel. Miami-Dade participants were the only ones who suggested another fishery was acting inappropriately as a whole. Those in Monroe might have identified a handful of
individuals who are presenting problems to their work, but not an entire section of the industry.

There is a benefit to the presence of an association for these fishermen with respect to agency involvement. Responses from Miami-Dade participants displayed an uncertainty and perhaps severe misunderstanding about the regulations in place which impact them directly. One example is the consequence of a lost trap being collected by the FWC. A participant suggested a range of fines associated with lost gear, once claiming $100 for lost traps, and $200 a few moments later. While several lost traps may result in these types of fines, the actual cost is $5 per recovered trap. The first 5 recovered traps per fisherman are waived through the endorsement fee for all commercial trap licenses.

The participant also indicated that there was jail time associated with the retrieval of lost gear by one fisherman for another. Another suggested serious consequences for touching another fisherman’s traps, even more serious for handling derelict traps. While the actual fines for handling another fisherman’s traps are severe⁷, participants in Miami-Dade County were not aware that programs existed that permit traps to be removed by commercial fishermen when sanctioned by the FWC. While other Miami-Dade responses did not specify the regulations on derelict gear, all understood which agency was responsible for employing them and that it required them to remove their traps at the end of the season. They agreed they were in place to improve the quality of the habitat and their fisheries, but did not understand consequences and other benefits to the trap removal program being in place.

⁷ “Tampering with traps, trap contents, lines or buoys that do not belong to you (even if the traps are derelict or in the water during a closed season), may result in a third degree felony conviction, fines of up to $5,000 and the permanent revocation of your fishing privileges.” (FWC, 2011)
There was a participant in Monroe who expressed disappointment in government decisions which had not fulfilled a promise to the commercial fishing industry. While they were, for the most part, supportive of agency decisions regarding marine debris, it was clear that if decisions were made without their input or without the intention to follow through on benefits promised to the industry they would not support those initiatives. This conditional support is well justified. General opinions of commercial fishermen throughout the study area suggested that they were happy with regulations on their industry if justified, well explained and done with the consideration of their opinions and needs. By developing a relationship with commercial fishermen in Monroe, FWC and Sea Grant have been able to communicate their plans to the industry representatives who act as a liaison between the two. For the purposes of these decisions and regulation development, the presence of an association for commercial fishing has been an asset.

3.5 Conclusions

3.5.1 Limitations and Applications
This perception study was initially designed as a series of focus groups in both Miami-Dade and Monroe Counties. It was aiming to collect perceptions from 10-20 subjects in each county who are involved in the commercial fishing industry, specifically targeting trap fisheries. Due to time constraints, fishing seasons and timing of the project, the design had to be altered to maximize productivity with limited resources. Only three participants in Miami-Dade were included and five in Monroe were included. Though limited in numbers, the contacts made with these individuals provided the information needed to meet the basic objectives of the project. Although an ideal scenario would involve a greater number of individuals, unforeseen circumstances prevented the
inclusion of more participants. While this perception study includes a small sample of potential perceptions, they may still be integral in developing a working relationship between fishers and scientists in resource management (Bunce et. al., 2008).

There are no known studies which focus on the perceptions of Miami-Dade commercial fishermen, nor were any located which include interviews and discussions with this population. By contrast, studies utilizing Monroe County fishermen (Suman et. al., 1999; Shivlani and Milton, 2000) have been carried out. These perceptions were gathered at times when regulatory decisions or management practices were shifting in the commercial fishing sector. There are no known perceptions studies in Monroe County which have been conducted within the last 5 years to account for current perceptions. Populations in Monroe County, although sometimes indicating a distrust or disagreement with agency decisions, have been more accessible given there population demographic and association base. Miami-Dade commercial fishermen are less willing to involve themselves in agency research or management development due to an apparent distrust. Contacts working with Miami-Dade commercial fishermen indicated that they view these types of involvements as a waste of incredibly valuable time.

In a study by Suman et. al. (1999), Saltwater Product License (SPL) holders were interviewed to gain their perception and attitudes towards zoning plans for the FKNMS. Using contacts from trap houses, commercial associations, Sea Grant Extension Agents and phone calls, a random sample of 337 commercial fishing participants were included. Having a sample of this size, which represented nearly 15% of all SPL holders in Monroe County, would allow for the present study to be analyzed at a statistical level. If continued and expanded over time, more participants from both Miami-Dade and Monroe
County should be sought out to include more personal interviews and, eventually, develop a statistically significant sample size.

As this perception study is non-statistical, it should be approached as a narrative study of the perceptions and opinions provided by commercial fishermen from Monroe County and Miami-Dade County. All participants from Monroe County are from the middle and upper Florida Keys. All participants in Miami-Dade are from the Miami River. There are a number of fishermen in each county who fish outside of these areas. This collection of perceptions is not necessarily representative of every single individual involved in commercial fishing in the study area. The project must be examined with the understanding that this is a small sample of individuals from that population.

The two populations sampled provided two very different conditions in which interviews were conducted. In Monroe County, all except one interview was conducted in person with a lead representative of the FKCFA present. The presence of this representative may have influenced responses to questions. Participants may have provided different responses, spoken more or shared less if they had been interviewed individually. Those in Miami-Dade were interviewed over the phone after their information had been provided by a contact in the local industry. In both counties, participant information or access was provided by these initial contacts. They were given information on the project and so had discretion on who to select and who to pass along to the project.

Limitations in the individuals surveyed also included language and association affiliation. Only English speakers were included, which could severely limit the number of participants available in the study area. By providing this limitation, survey responses
were excluding a population that is present in the industry and may provide a different view on these issues and concepts. All participants in Monroe County were members of the FKCFA, which does not include all commercial fishermen in the Florida Keys. While there are benefits to being a member, participation is not required of all commercial fishermen. Those who are association members are more informed of regulatory developments, agency involvement and research initiatives in their fishing ground.

3.5.2 Role of Commercial Fishermen in Marine Debris
Commercial fishermen have the capability to contribute large quantities of fishing gear to marine debris accumulation along the FKRT. With some individuals deploying thousands of traps, there is an ever increasing risk for loss with storms, propeller strikes, and illegal fishing practices like trap robbing. With “Trap” debris dominating the marine debris observations of RVC surveys, it was anticipated that trap fisheries were acting in ways which were negatively impacting the habitat and increasing potential for derelict gear accumulation. Since these traps can only be utilized by commercial fishing participants with appropriate licensing, their actions seemed to be the cause of “Trap” debris prevalence.

The importance of incorporating a perception study of these individuals is emphasized by the dominance of their fishing gear in the RVC database. In reviewing results from these interviews, it seems even more important to have their perceptions and opinions alongside actual observations of debris. Commercial fishermen did not refute the presence of debris, but they did refute the idea that it was intentionally left in the environment or that its presence should be allowed. Some fishermen seemed surprised that we would find so much trap debris on the reef habitat, since they would never
intentionally set their traps in this location. Traps are set away from the reefs, frequently in or near sea grass beds. As noted in the NWHI, debris may be observed in unanticipated locations and indicate its origin is elsewhere due to oceanographic conditions (Donohue et al., 2001). Although trap gear is seen on reef structures or within SPAs, it does not mean it originated here.

Although not a focus during RVC dives, sea grass habitats provide critical ecological functions, such as nurseries, settlement sites and refuge areas. While wood traps, like spiny lobster traps, degrade within about two years, they have the ability to damage sea grass habitats as they move with currents and storm events (Uhrin et. al., 2005). Habitat impacts by spiny lobster traps have been explicitly studied by Matthews et. al. (2011), which concluded nearly 4.5 square meters of benthic damage per lost trap. With over 1.2 million permits for spiny lobster and stone crab traps in Southeast Florida alone (Uhrin et. al., 2011), the risk of habitat degradation extends beyond offshore reef habitats.

The loss of gear represents a significant financial loss to commercial fishermen. They would take every action possible to recover lost gear. While they tie derelict gear to environmental problems, it is predominantly tied to financial issues. Commercial fishermen who do not retrieve their gear or attempted to recover it appear to not be well respected by others in their industry. Those who do contribute to the problem are grouped in to the categories of “lazy” and “ignorant” by those participants interviewed.

Some fishermen indicated debris was a result of recreational fishing activities, beyond those that may result in trap lines being cut. The suggestion that recreational fishing contributes to the majority of marine debris in the FKRT with high volumes of
monofilament left behind supports results from previous marine debris surveys along the reef by Chiappone et. al. (2002, 2004, 2005). These indicated recreational “hook and line” gear dominated debris presence over commercial “Trap” gear. However, differences in survey methodology and visual recognition can lead to discrepancies in data.

As noted by Cook and Cowx (2006), determining the origin of lost and derelict fishing equipment can be difficult. This is especially true when discussing materials such as line, which is found in the RVC survey under both “Other” (21%) and “Trap” (20%) categories. Some line could have been associated with recreational activities and some may have been the result of derelict traps or other commercial activities. Differentiating between those two is up to the observer. This leaves the possibility that this gear is a result of either commercial or recreational actions. Regardless, alterations in the actions of just one user group could significantly reduce the presence of marine debris in the study area.

Participants indicated that commercial fishermen, as a whole, act in the best interest of their fishery, which has grown to include the environmental responsibility of reducing marine debris. While their gear and practices present a potential for massive marine debris accumulation, their actions also have the potential to prevent this from occurring. Their gear which is being observed entangled in reefs was not placed there intentionally. Gear observed off of the reefs may have been discarded intentionally or lost, but no fisherman described setting traps on the reef habitat. Most were surprised when explained how much trap gear was observed on the reefs because they do not set their gear in these locations. This indicates their practices are not what directly contribute to derelict fishing gear, but the concerns of storms and boat traffic cutting lines.
3.5.3 Proposed Removals

In general, industry participants indicated an interest in being involved with removal efforts. The biggest incentive for participants was the improvement of their fishing habitat and the environment they are dependent on. There was actually a concern that their actions are perceived as financially driven. They were quick to remind that their involvement in removals have occurred for years even when financial gains did not exist. Their actions, as expressed in this study, are for the benefit of their industry and the marine environment. When pressed for priorities, financial gains would come out on top, but the industry has an understanding that certain actions would improve their fishing grounds and could become an ultimate gain.

Commercial fishermen should be included in submerged marine debris removals whenever possible. This population has the local knowledge of currents and tides that most recreational users don’t even have. Participants from the perception study were only willing to participate in removals with their vessel if it was an area they were familiar with. They also acknowledged the risks of not participating and leaving it up to an inexperienced boater. There was a general concern that those who don’t know the waters could end up causing more harm than good. These types of removals, integrating commercial user and agency actions, could provide a model for other regions conducting removals.

Since 1996, inter-agency derelict fishing gear removal in the Northwestern Hawaiian Islands has been conducted. Highly successful, the removals have extracted upwards of 18,500 pounds of derelict fishing gear in one year. Though exclusively targeting commercial fishing gear, industry participants have not been included in these
efforts (Donohue et. al., 2000). By involving participants who have the capability to slow introduction of debris into the environment, they may be more inclined to take appropriate actions to reduce input of their gear. They also provide unparalleled knowledge of local marine habitats. They should be included to not only motivate appropriate disposal of gear but to enhance removal effectiveness.

Removals that have been proposed for the targeted areas of Miami-Dade waters (Figure 20) would be carried out with the assistance of commercial fishermen. When approaching potential participants, there are three specific considerations which must be met to ensure successful involvement. These points include (1) time of the year, (2) financial burdens or incentives and (3) distance from dock. Removals should be conducted during a time of the year which interferes the least with trap fishery seasons. Although there are closure periods for spiny lobster, stone crab and blue crab fisheries, they do not coincide. Spiny lobster closes from the start of April until August, stone crab closes May through October and blue crab closures occur throughout the state in a rotation of 10-day periods throughout the year. Miami-Dade and Monroe County both close their blue crab fisheries in early to mid-July on odd years.

Ideally, removals would take place during the blue crab closure period since there are no other trap fisheries operating at this time. When asked, most fishermen were interested in participating during this time since it would be a slow time for them. Although their interest in participating was not financially driven, many cited it as beneficial to be paid during a time when they have no other income. When approaching fishermen, incentives should not be offered up instantly. When financial assistance is brought into the equation, interest levels and participants shift. It would be more effective
to gather those who are truly interested in helping by not offering financial incentives. The only distribution of funds will be to offset costs of fuel and crew to participating fishermen, and which account for the biggest losses in trap removals for participants.

Although many participants indicated they would be involved with removal efforts even without payment, it has become standard practice for those who have participated in FWC removals in the past to receive payment for the number of traps they recover. While this may be a limitation for Monroe County fishermen, Miami-Dade fishermen have not been involved in trap debris removal efforts. There is no expectation from the group from Miami-Dade to receive financial gains from participation. No participants from Miami-Dade even suggested payment as incentive for participation, giving only time of year as a limitation.

Distance from dock will limit the fishermen who can be involved. While participants in the perception study were docked as far south as Marathon, they were still somewhat interested in assisting for Miami-Dade removals. Contact with fishermen in the Upper Keys and Key Largo indicated a stronger willingness to participate due to proximity and expected fuel costs. Fishermen to be contacted and recruited should be from the Upper Keys and Miami River, as these are two groups who have had contact with the project, have expressed willingness to participate and are located closest to the proposed removal locations.

Although Monroe County fishermen will provide prior experience in trap removal events, gear for hauling debris and local knowledge, Miami-Dade fishermen will be an asset to the project. Just as removals conducted by FWC and the involvement of Sea Grant has improved relationships between the industry and agencies in Monroe County,
this is an opportunity to do so in Miami-Dade. By utilizing information from NOAA Fisheries through a Sea Grant sponsored project to benefit commercial fishing through regulations provided by FWC, perceptions of these agencies may shift to the positive. This project may be used a mechanism to improve relationships between commercial fishing and local and state agencies to improve the quality of regulatory development and industry compliance. It may also provide an opportunity for commercial fishermen throughout southeast Florida to work cooperatively when many would not ordinarily do so. This is especially important for a region like Miami-Dade, where a lack of association or organization prevents collective efforts by the commercial fishing industry.

3.5.4 Recommendations

3.5.4.1 Reporting Mechanism and Disposal

Regulations on derelict fishing gear are implemented to ensure an equitable form of debris removal. Lost gear is an accepted, though negative, consequence of trap fisheries. This is reflected in the current endorsement fee for all commercial licenses for trap fisheries. Twenty-five dollars ($25) of the endorsement fee provides a “waiver” to fishermen for the loss of up to 5 traps, since the fine for recovered traps during the Spiny Lobster, Stone Crab and Blue Crab Trap Retrieval Program is $5. After the first 5 recovered, fishermen are fined the rate of $5 per trap (FWC, 2009). This allowance displays recognition that trap loss is anticipated and accepted.

Unfortunately, there are a number of instances in which industry participants cited trap loss. Most commonly, storms and propeller strikes cause traps to be lost. As long as the buoy is still attached to the trap, fishermen have hope of finding and recovering them. Once that line is cut, the trap becomes submerged debris and can only be found by physically scanning the bottom. Some fishermen in Monroe had discussed technology
available on their boat which allows them to see traps which are submerged, but they can’t know if it is their trap until it is recovered with identifying tag numbers intact. When traps are lost on the reef, they are typically too deep to be recovered by fishermen alone.

Most responsible fishermen will make every effort to recover their traps. They also know the locations of their traps and know where and when they might have been lost due to a storm or propeller strike. Currently, there is no way for a fisherman to report a lost trap. Even if fishermen take every possible precaution to prevent its loss and make every effort to recover it, its collection through the Spiny Lobster, Stone Crab and Blue Crab Trap Retrieval Program will result in financial penalties. If trap loss is viewed as accepted in minimal amounts (5 or less traps), there should be a mechanism to report lost gear in a valid and responsible way. By providing information on location, date and type of trap gear lost, reporting fishermen can help generate data that can be utilized in future removal efforts. Current removals in Monroe County are reported to remove less than 5% of all derelict traps present (Uhrin et. al., 2011). Rather than waiting to see where traps are found on removal events, advance information from fishermen could help to increase efficiency and relationships between the industry, research initiatives and local agencies.

Fishermen collectively indicated a desire for the recovery of trap materials for reuse, though indicated different uses. Some suggested trap parts, especially buoys, can be sold by fishermen or the FWC as “souvenirs” to visitors. These profits would be returned to the debris removal program and could be used to fund future efforts. During removals following natural disasters, fishermen have the opportunity to reclaim their
traps 10 days following the removal. This suggests that since storm loss is of no fault to the fishermen, they should have the right to reclaim their gear.

Trap disposal has been described as a major cost to trap yards. Tipping and hauling fees can add up quickly. One contact estimated that disposal of debris can cost upwards of $120 per ton. Debris disposal costs can exceed $1,000 from one day of efficient and effective removal. Fishermen from Monroe and Miami-Dade indicated that the required disposal of trap gear is wasteful and has no economic benefit. For an industry that believes in efficiency and maximizing efforts, disposing of perfectly good gear is incredibly wasteful. One participant in Miami-Dade indicated a desire to return recovered traps to fellow fishermen if it could be identified, but acknowledged the current law prevents such actions.

If commercial fishermen are allowed to responsibly report the loss of trap gear with coordinates and dates it was last seen, they should be permitted to recover or buy back their trap at a price if found during removals. This could occur during a 10-day period, just as in natural disaster removals. After those 10 days, gear could be sold to any fisherman who participated in the removal at a price. All profits would be turned back into the removal program to support fishermen participating and research initiatives in marine debris and derelict fishing gear. This would minimize debris hauling costs and waste generation while and maximizing efforts.

3.5.4.2 Miami-Dade Removals
Large-scale removals of submerged marine debris and derelict fishing gear have been successful in Monroe County for almost two decades. Initially developed as volunteer efforts by commercial fishermen, the FWC partnered with the industry in the mid 1990’s to develop more effective removals and provide financial assistance to those
involved in removals. With the influx of FEMA grants and support after the 2005 and 2006 hurricane seasons, derelict gear removal began to incorporate more members of the commercial fishing community. It also provided more financial gain to being involved and some suggest it altered the motivation for participation.

The relationship between the commercial fishing industry and agencies supporting marine debris removal is strong in Monroe County. Although not always in agreement of decisions or actions by the other, the two have worked to benefit the environment and industry. Much of it is attributed to their association’s collaboration with agencies and representing their needs as these efforts have developed. In Miami-Dade, there is no acting representative of the industry to speak for them or to develop a relationship between the two. Proposed removals in Miami-Dade will take initial steps to introducing the commercial fishing industry to joint efforts with agencies and other fishermen.

Removals should be conducted utilizing data from the existing RVC dataset and provided GIS maps of high debris observation density regions. Records of marine debris on RVC dives should utilize the proposed datasheet to allow for streamlined data entry and annual updates of GIS mapping. This will eventually lead to more specific locations to focus removal efforts. These actions should be conducted with the goal of developing a cost-effective and efficient method of community-based marine debris removals for Miami-Dade County. These should occur during blue crab and/or Caribbean spiny lobster closures annually to prove a regular removal event for Miami-Dade County and minimize debris accumulation over time, contributing to ongoing mitigation efforts.
It may be prudent to initiate removals in Miami-Dade without the promise of financial gain or incentives. Through this project, it was found that most fishermen will act in a way to benefit their fishing grounds. Most of the interviewed fishers understand that debris left in the marine environment would ultimately impact their fishing and recognize the harm it can do to the environment. They expressed a willingness to participate and to encourage fellow trap fishermen to participate in this type of event. The only financial assistance provided should be in the form of cost recovery for crew and fuel.

Removals should be designed to allow the commercial fishing industry in Miami-Dade to see the support available from local agencies, but should not be developed as a way to “pay-off” their support. Just as the type of involvement changed in Monroe County with additional funding, the motivation for participating and contributing resources by participants would be altered in Miami-Dade with the promise of additional payment. There is also the concern that if compensated monetarily once, participants will expect it in the future. Since this cannot be promised, payment for trap retrieval should be excluded at all costs.

These removals should begin to incorporate the disposal and buy-back mechanisms suggestion in the previous section. As debris is removed, any intact traps with identifiable numbers should be retained in a reclamation location at a designated trap yard where disposal is occurring. During initial removal events, commercial fishermen who participate in removals should have the opportunity to buy back their traps at a reduced rate. This opportunity would be closed to commercial fishermen participating in that year’s removal. As events continue on an annual basis, a reporting
system should be developed with the assistance of Sea Grant and FWC. Any commercial fisherman who has, by a specified deadline, reported the numbers and GPS coordinates of lost gear may participate in the buyback program. All funds generated through this would be directed to support future marine debris programs in Miami-Dade County.

While trap line alone cannot be resold, line attached to buoys or individual buoys may be sold to individuals outside the commercial fishing community. Participants in the project’s perception study indicated that buoys could be successfully sold to visitors to Southeast Florida as souvenirs. Buoys from removal events may be sold to select vendors with all funds being returned to support future marine debris programs in Miami-Dade County. These vendors would have the opportunity to build a positive relationship with the commercial fishing industry while promoting their business as one supporting local industry and the health of the FKRT.

3.5.4.3 Outreach and Education
There are two groups which outreach and education should target regarding marine debris removal in Southeast Florida. There was an expressed desire from commercial fishermen throughout the study area for more informed recreational users. While education of the general public on the care and quality of our marine environment is essential, not every negative action by the public is entirely intentional. The sources of marine debris stem entirely from human actions; ignorance, laziness and accidents. Though some of these will persist, there are ways to minimize debris influxes by instilling stewardship through local education.

3.5.4.3.1 Recreational Outreach and Education
Commercial fishermen in the region are aware of marine debris. They are aware that leaving any materials in the ocean can be harmful and is an illegal action. While their
gear may be a large source, their actions are typically not. Public education with respect
to marine debris generally addresses the point that throwing materials overboard a vessel
or inappropriate disposal of trash is a negative action. However, their potential
contribution to derelict fishing gear may not be explained. Education for recreational
divers, fishermen and boaters needs to include the impacts on trap fishing and how these
affect the marine habitats they enjoy. Submerged debris can present a problem in
education since it is very much “out of sight, out of mind”. Debris education should be
visual and present issues that are critical on a local level. Correlating how one person’s
actions can negatively impact the environment they are enjoying can be incredibly
effective.

Boaters should be provided with information on how to avoid running over trap
line and buoys. Potential impacts to their own vessel or equipment should be included to
provide incentive for interest, rather than maintaining the idea that they are the only
problem and commercial traps are the only impact. Eco-tourism, dive boats and charter
fishing groups can educate their customers by encouraging the presence of traps as a
positive, rather than a negative. Recreational users should treat commercial fishing traps
with respect in the same way they would respect the natural resources they are utilizing.
While they are not natural in the environment, their presence while fishing does not
degrade the FKRT. However, these habitats are fragile and sensitive. When damaged in a
way to prevent users from fishing as intended, marine debris can provide serious threats
to the marine ecosystem. Fisherman actions in setting traps should not be conveyed to
the public as negative, but as responsible and careful. The public’s perception of
commercial fishing should encourage respect of their efforts.
3.5.4.3.2 Commercial Fishing Outreach and Education
The second group in the study area which should be targeted is the commercial fishing community in Miami-Dade County. Based on the interviews, this population has misconceptions and minimal understanding of certain laws, regulations and potential support for derelict traps and marine debris in the region. This gap between scientific knowledge, management and resource-user perceptions has been previously noted in Miami-Dade County (Bhat and Stamatiades, 2003). Participants interviewed in the project were unclear on their penalties for lost traps, indicating a wary respect for the regulations without real understanding of their purpose or actual intention. There was also a general mistrust of agencies involved in fisheries and habitat management. Using proposed removals, fishermen from Miami-Dade who participate should be invited to comment on regulations or actions by local agencies. Although suggested their time is too valuable to be wasted on meetings and discussion, the fishermen indicated a desire to know more about these groups involved in their industry.

The study’s commercial fishing representatives in Miami-Dade County can be compared to the participants interviewed through the 1995 survey by Suman et. al. (1999), gathering perceptions regarding marine reserves in the FKNMS. Limited to Monroe County commercial fishers, the study utilized a random sample of SPL holders and resulted in 337 commercial fishing participants. While a statistically significant population, both used personal interviews and emotional responses to gather perceptions. However, perceptions of agency decisions and actions were more negative in this population nearly 10 years ago. The study reported commercial fishermen felt “frustration and powerlessness” against these actions, indicating agency processes would continue regardless of the opinions of commercial fishermen (Suman, et. al., 1999).
These responses reflect those of Miami-Dade commercial fishermen currently, where distrust for agencies and a lack of awareness seems to be prevalent.

Participants in Monroe indicated a more positive and inclusive perception of agency actions and involvement. They feel their opinions are voiced through the involvement of their Sea Grant Agent and FKCFA in management decisions. These perceptions have developed over the last decade and can be attributed in increased collaborative efforts between commercial fishermen and agencies, including FWC and Sea Grant. This suggests building relationships within Miami-Dade County between commercial fishermen and local agencies may take some time, but could lead to improved decisions and management of our marine resources. A critical step in fostering this type of relationship is to bring information to commercial fishermen while offering inclusion through management decisions.

Using the information gained in this limited study, the inclusion of Miami-Dade commercial fishermen is more essential than ever. Perceptions and attitudes towards marine debris are not drastically different from those in Monroe County, but the awareness of appropriate actions and support for their industry is lacking. As seen with Monroe County fishermen in the late 1990’s, there were misunderstandings and a lack of respect for agency involvement in marine management (Suman et. al., 1999). Monroe County fishermen involved in this project expressed their support for local agencies and were proud to be involved with management decisions by FWC and NOAA Fisheries.

This relationship is one that should be fostered in Miami-Dade. Their involvement should be reciprocated with assistance from local agencies to involve them with decisions made regarding their fishing habitat. While both Florida DEP and FWC are influential in
management of the FKRT, the Miami-Dade County Florida Sea Grant Extension Program should be the primary agency involved in commercial fisherman inclusion.

Future work initiated by this project should take the information developed through initial interviews and expand upon them to include more commercial fishermen across Southeast Florida, especially in Miami-Dade County. The commercial fishing industry in Miami-Dade County needs to understand the laws and regulations they are expected to follow, but also which of these are designed to protect their livelihood. Perceptions should continue to be tracked and monitored as relationships between local agencies and commercial fishermen develop to determine how critical this element is to responsible management decisions and resource protection (Bunce et al., 2008).

Responsible for providing scientific information to the public and supporting decision-making based on local interests and stakeholders, Sea Grant is an ideal program to link commercial fishermen and marine debris mitigation. Debris observation density maps produced through this project should be provided to commercial fishermen and industry representatives to increase awareness of current debris locations. While participants in this study indicated an awareness of marine debris, they were uncertain of locations it is currently found. Providing them with known regions debris has been observed may promote awareness of submerged debris distribution and potentially aid them in retrieving their own gear.

Participants from the project’s perception study should be the first group targeted in meetings to discuss plans for removal events, existing regulation and introduce agency presence in the region. These meeting should be led by Sea Grant, with the assistance of an individual who the commercial fishing industry is familiar with and can trust should
be present. Members from the Department of Environmental Resource Management (DERM) or Miami River Commission have an existing relationship with commercial fishermen from Miami-Dade County and should be utilized in developing in-person meetings.

Initial meetings should be informal and occur on a small scale, held in accessible locations at convenient times. Most commercial fishermen identify as part of a specific trap house and the arrangement of meetings should be structured around these pre-existing social structures. Informal discussions led by Sea Grant with assistance from an additional representative and trap yard or fish house owner should be open to any interested participating fisherman. Groups should meet briefly for information on regulations, a forum to discuss their concerns and learn ways in which these agencies can assist their industry. Developing these small, informal groups associated with their trap yard or fish house may provide a basis for commercial fishermen to form an associate and unified front as found in Monroe County. This development will occur over time and an instantaneous change in behavior or perception cannot be expected. However, building a trust among the industry and outside towards agencies is a critical step in improving relationships and future programs.

Commercial fishermen should not be discounted as an irresponsible or non-environmentally conscious population. They are the exact opposite of this perception. They are dependent on a fragile resource and make every effort to preserve it while involved in an invasive industry. Though there are some who are not responsible, not aware and not invested in maintaining the health of the marine environment, those may be the minority. Education of the public should be geared toward the support of their
practices and education of commercial fishermen should be used to explain the presence of regulations while considering their intentions and actions.

Marine debris along the FKRT is not the result of one user group’s actions, an individual law or regulation, nor is it the problem of one population. Marine debris is present because of collective ignorance, misunderstandings and a lack of education. While the problem would not resolve itself anytime soon, efforts should be made to incorporate as many populations contributing to the problem as possible. The collective education, understanding and actions of these groups may provide the best possible mitigation and solution to marine debris along the FKRT.
Figure 1. Map of the FKRT and designated protected areas. FKNMS bounded in blue while National Parks, including Biscayne Bay, are bordered in red. The FKNMS extends along Biscayne National Park to its northernmost boundary (FKNMS, 2001).
Figure 2. Original RVC datasheet used by divers during survey periods. All marine debris observations were noted in the “Fishing Gear” section. Lines in the species identification section were removed for clarity in this document only. Actual RVC data sheets include more space to enter species observed.
Figure 3. Suggested edits to RVC datasheet to emphasize marine debris monitoring. “Fishing Gear” has been changed to “Submerged Debris” and gives three options for divers to select from. Space preceding each category allows divers to enter the number of each observed in their cylinder. Lines in the species identification section were removed for clarity in this document only. Actual RVC data sheets include more space to enter species observed.
Figure 4. Current revisions to RVC datasheet being considered for inclusion. “Fishing Gear” has been changed to “Submerged Debris” and gives three options for divers to select from. Space after each category allows divers to enter the number of each observed in their cylinder.
Figure 5. Total marine debris observations from 2002-2010 along the Florida Keys Reef Tract study area.
2002-2010 Marine Debris Observation by Category

Legend
- Florida

Category
- Fishing
- Other
- Trap

Figure 6. Marine debris observations 2002-2010 by category of debris.
Figure 7. Marine debris observation density for all observations 2002-2010 per one square mile. Orange and red indicate areas of highest concentration.
Figure 8. Marine debris concentrations from 2004 RVC dives. Orange and red indicate highest debris concentrations per square mile.
Figure 9. Marine debris concentrations from 2005 RVC dives. Orange and red indicate highest debris concentrations per square mile.
Figure 10. Marine debris concentrations from 2006 RVC dives. Orange and red indicate highest debris concentrations per square mile.
Figure 11. Marine debris concentrations from 2007 RVC dives. Orange and red indicate highest debris concentrations per square mile.
Figure 12. Marine debris concentrations from 2008 RVC dives. Orange and red indicate highest debris concentrations per square mile.
Figure 13. Marine debris concentrations from 2009 RVC dives. Orange and red indicate highest debris concentrations per square mile.
Figure 14. Marine debris concentrations from 2010 RVC dives. Orange and red indicate highest debris concentrations per square mile.
Figure 15. Marine debris observations within SPA boundaries 2002-2010.
Figure 16. Habitat classifications along the FKRT determined by debris sightings along the FKRT. This not a precise image of habitat types. Spur and groove formations dominate offshore of the keys, while most isolated reefs are found north towards Biscayne Bay.
Figure 17. Marine debris observations within Biscayne study area 2002-2010. Debris points are categorized by type of debris.
Figure 18. Density of debris points observed along the reef tract east of Biscayne Bay from 2002-2010.

Figure 19. Debris observed along the reef tract east of Biscayne Bay from 2002-2010. Debris points are layed over habitat classifications for the Biscayne study region.
Figure 20. Proposed removal locations in Miami-Dade County for targeted removal events based on high observation density annually and cumulatively. Red boxes indicate the total area in which dive locations should be considered. Specific locations within these suggested areas can be determined using RVC 200x200m grid squares.
5. Tables

<table>
<thead>
<tr>
<th>Fishing</th>
<th>Trap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast Net Lead Line</td>
<td>Fish Trap</td>
</tr>
<tr>
<td>Fishing Gear</td>
<td>Lobster Trap</td>
</tr>
<tr>
<td>Fishing Lure</td>
<td>Lobster Trap</td>
</tr>
<tr>
<td>Fishing Pole</td>
<td>Lobster Trap Buoy</td>
</tr>
<tr>
<td>Fishing Rod</td>
<td>Lobster Trap Debris</td>
</tr>
<tr>
<td>Leader</td>
<td>Lobster Trap Line</td>
</tr>
<tr>
<td>Monofilament</td>
<td>Stone Crab Trap</td>
</tr>
<tr>
<td>Net</td>
<td>Stone Crab Trap Line</td>
</tr>
<tr>
<td>Pole</td>
<td>Trap Buoy</td>
</tr>
<tr>
<td>Reel</td>
<td>Trap Debris</td>
</tr>
<tr>
<td>Rod</td>
<td>Trap Line</td>
</tr>
<tr>
<td>Rod and Reel</td>
<td></td>
</tr>
<tr>
<td>Rod Holder</td>
<td></td>
</tr>
<tr>
<td>Spear</td>
<td></td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td><strong>Dive Flag Parts</strong></td>
</tr>
<tr>
<td>A/C Unit</td>
<td>Line</td>
</tr>
<tr>
<td>Anchor</td>
<td>Line (Undefined)</td>
</tr>
<tr>
<td>Anchor Line</td>
<td>Lobster Burlap Bag</td>
</tr>
<tr>
<td>Auto Wheel Rims</td>
<td>Mesh Bag</td>
</tr>
<tr>
<td>Bait Buckets</td>
<td>Metal</td>
</tr>
<tr>
<td>Boat Debris</td>
<td>Metal Grate</td>
</tr>
<tr>
<td>Bottle</td>
<td>Mooring ball anchor point</td>
</tr>
<tr>
<td>Cable</td>
<td>Pipe</td>
</tr>
<tr>
<td>Chain</td>
<td>PVC Pipe</td>
</tr>
<tr>
<td>Chum Bag</td>
<td>Trash</td>
</tr>
<tr>
<td>Concrete Block</td>
<td>Vessel Debris</td>
</tr>
</tbody>
</table>

Table 1. Current RVC database marine debris categories and subcategories. Categories are those listed in bold (Fishing, Trap and Other). Categories and subcategories are determined based on entries from divers during field observations.
### Dive Effort by Habitat

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Total</th>
<th>Frequency of Dives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artificial</td>
<td>28</td>
<td>0.006</td>
</tr>
<tr>
<td>Contiguous Low-Relief</td>
<td>984</td>
<td>0.198</td>
</tr>
<tr>
<td>Isolated Low-Relief</td>
<td>338</td>
<td>0.068</td>
</tr>
<tr>
<td>Isolated Mid-Relief</td>
<td>1345</td>
<td>0.271</td>
</tr>
<tr>
<td>Rubble Low-Relief</td>
<td>188</td>
<td>0.038</td>
</tr>
<tr>
<td>Sand</td>
<td>54</td>
<td>0.011</td>
</tr>
<tr>
<td>Seagrass</td>
<td>1</td>
<td>0.0002</td>
</tr>
<tr>
<td>Spur and Groove High-Relief</td>
<td>785</td>
<td>0.158</td>
</tr>
<tr>
<td>Spur and Groove Low-Relief</td>
<td>1185</td>
<td>0.239</td>
</tr>
<tr>
<td>Undefined</td>
<td>54</td>
<td>0.011</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>4962</strong></td>
<td></td>
</tr>
</tbody>
</table>

### Debris Presence by Habitat

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Total</th>
<th>Frequency of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contiguous Low-Relief</td>
<td>180</td>
<td>0.175</td>
</tr>
<tr>
<td>Isolated Low-Relief</td>
<td>73</td>
<td>0.071</td>
</tr>
<tr>
<td>Isolated Mid-Relief</td>
<td>328</td>
<td>0.319</td>
</tr>
<tr>
<td>Low-Relief</td>
<td>8</td>
<td>0.008</td>
</tr>
<tr>
<td>Sand</td>
<td>4</td>
<td>0.007</td>
</tr>
<tr>
<td>Seagrass</td>
<td>1</td>
<td>0.001</td>
</tr>
<tr>
<td>Spur and Groove High-Relief</td>
<td>103</td>
<td>0.1</td>
</tr>
<tr>
<td>Spur and Groove Low-Relief</td>
<td>325</td>
<td>0.316</td>
</tr>
<tr>
<td>Undefined</td>
<td>5</td>
<td>0.005</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>1027</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Dive effort and debris presence by habitat. Both values recorded as a frequency of total debris observations and dives from 2002-2010.
Table 3. Dive effort and debris presence by subregion. Both values recorded as a frequency of total debris observations and dives from 2002-2010.

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Total</th>
<th>Frequency of Dives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biscayne</td>
<td>1276</td>
<td>0.257</td>
</tr>
<tr>
<td>Lower Keys</td>
<td>1301</td>
<td>0.262</td>
</tr>
<tr>
<td>Middle Keys</td>
<td>428</td>
<td>0.086</td>
</tr>
<tr>
<td>Mid-Upper Keys Transition</td>
<td>493</td>
<td>0.099</td>
</tr>
<tr>
<td>Upper Keys</td>
<td>1464</td>
<td>0.295</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>4962</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Habitat</th>
<th>Total</th>
<th>Frequency of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biscayne</td>
<td>332</td>
<td>0.323</td>
</tr>
<tr>
<td>Lower Keys</td>
<td>200</td>
<td>0.195</td>
</tr>
<tr>
<td>Middle Keys</td>
<td>98</td>
<td>0.095</td>
</tr>
<tr>
<td>Mid-Upper Keys Transition</td>
<td>86</td>
<td>0.084</td>
</tr>
<tr>
<td>Upper Keys</td>
<td>311</td>
<td>0.303</td>
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<tr>
<td><strong>Grand Total</strong></td>
<td><strong>1027</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Dive effort and debris presence by management zones. All 22 observed SPAs are displayed cumulatively. Both values recorded as a frequency of total debris observations and dives from 2002-2010.

<table>
<thead>
<tr>
<th>Management Zone</th>
<th>Total</th>
<th>Frequency of Dives</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPA</td>
<td>1184</td>
<td>0.239</td>
</tr>
<tr>
<td>Unprotected</td>
<td>3778</td>
<td>0.761</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>4962</strong></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Management Zone</th>
<th>Total</th>
<th>Frequency of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPA</td>
<td>152</td>
<td>0.148</td>
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<tr>
<td>Unprotected</td>
<td>875</td>
<td>0.852</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>1027</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 5. Dive effort and debris presence by reef zone. Both values recorded as a frequency of total debris observations and dives from 2002-2010.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Total</th>
<th>Frequency of Dives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forereef</td>
<td>3407</td>
<td>0.687</td>
</tr>
<tr>
<td>Inshore</td>
<td>231</td>
<td>0.047</td>
</tr>
<tr>
<td>Mid Channel</td>
<td>755</td>
<td>0.152</td>
</tr>
<tr>
<td>Offshore Patch Reef</td>
<td>529</td>
<td>0.107</td>
</tr>
<tr>
<td>Undetermined</td>
<td>40</td>
<td>0.008</td>
</tr>
<tr>
<td><strong>Grand Total</strong></td>
<td><strong>4962</strong></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Zone</th>
<th>Total</th>
<th>Frequency of Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forereef</td>
<td>668</td>
<td>0.650</td>
</tr>
<tr>
<td>Inshore</td>
<td>38</td>
<td>0.037</td>
</tr>
<tr>
<td>Mid Channel</td>
<td>171</td>
<td>0.167</td>
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<tr>
<td>Offshore Patch Reef</td>
<td>148</td>
<td>0.144</td>
</tr>
<tr>
<td>Undetermined</td>
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<td>0.002</td>
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<tr>
<td><strong>Grand Total</strong></td>
<td><strong>1027</strong></td>
<td></td>
</tr>
<tr>
<td>Miami-Dade</td>
<td>Monroe</td>
<td>State</td>
</tr>
<tr>
<td>------------</td>
<td>--------</td>
<td>-------</td>
</tr>
<tr>
<td>Pounds</td>
<td>Trips</td>
<td>Pounds</td>
</tr>
<tr>
<td>Spiny Lobster</td>
<td>219,822</td>
<td>1,202</td>
</tr>
<tr>
<td>Blue Crab</td>
<td>46,561</td>
<td>544</td>
</tr>
<tr>
<td>Stone Crab</td>
<td>24,979</td>
<td>454</td>
</tr>
</tbody>
</table>

Table 6. Spiny lobster, blue crab and stone crab landings and trip numbers for 2009 in Miami-Dade and Monroe counties and Florida state totals. Stone crabs are listed as claw weight, rather than whole weight. One trip is defined as the time a vessel leaves the dock until the time the product is transferred. Data is finalized in July of the following year, making 2009 the most current data set (FWC, 2011).

<table>
<thead>
<tr>
<th>Spiny Lobster</th>
<th>Miami-Dade</th>
<th>Monroe</th>
<th>Statewide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$685,844</td>
<td>$12,191,506</td>
<td>$13,261,648</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Blue Crab</th>
<th>Miami-Dade</th>
<th>Monroe</th>
<th>Statewide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$56,338</td>
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<td>$1,060,708</td>
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<table>
<thead>
<tr>
<th>Stone Crab</th>
<th>Miami-Dade</th>
<th>Monroe</th>
<th>Statewide</th>
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<td>$165,111</td>
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Table 7. Estimated dockside values of spiny lobster, blue crab and stone crabs in Miami-Dade and Monroe counties. Statewide totals given were reported by FWC’s 2009 landing summary as the value per pound of landed fishery. Dockside values from the 2009 FWC landing summary were used to approximate values across Miami-Dade and Monroe County. County values are estimates based off of these values.
6. References


Ault, Jerald S. and Smith, Steven G. 2009. Ault-Smith notes on Reef-fish Visual Census (RVC) population statistics estimation for Black Grouper (Myceteroperca bonaci) and Red Grouper (Epinephelus mori) in the Florida Key and Dry Tortugas regions. University of Miami RSMAS.


Florida Department of Environmental Protection. 16 April 2011. Southeast Florida Marine Debris Reporting and Removal Program 1st Annual Clean-up Event: Summary. *Personal Contact*.


Ocean Conservancy. 2010. Trash Travels: From our hands to the sea, around the globe and through time.


7. Appendix A

Participant Interview Questions

1. Participating fishery:
2. How long have you been working in the industry?
3. Do you feel derelict fishing gear is a problem in the area you work? Why or why not?
4. Are you familiar with the FWC derelict trap removal program? Have you participated in a derelict trap removal project?
5. Do you ever come across materials which could be salvaged for reuse?
6. If you notice old or derelict fishing gear in an area, does it affect you or your fishing locations at all?
7. If you were to lose fishing gear, or it is damaged, would it be cheaper to purchase again, or attempt to find and repair the old one?
8. I’ve heard of situations where traps are lost for a range of reasons. When, if at all, do you lose gear or traps in the ocean?
9. Can you tell me anything about the trap incentive/buy back program?
10. What do you think is the biggest contributor to marine debris in your fishing area? How do you think it can be eliminated?
11. If you were to find a derelict trap or a noticeable amount of marine debris in the water, what, if any, actions do you take?
12. What is your relationship with FWC/DERM/NOAA fisheries/SeaGrant in the context of marine debris? Would you like more or less contact with them regarding marine debris?
13. What is your relationship with FWC/DERM/NOAA fisheries/SeaGrant etc? Would you like more or less contact with them?
   a. If they had information in marine debris, specifically derelict fishing gear, would you like to be made aware of locations and removal efforts?
   b. If a removal effort was taking place in Biscayne Bay, how would you feel about it? If you were asked to participate, given your knowledge of the area and impacts, would you be interested?
   c. What conditions would enable participation?
   d. What factors will disable you from participation?