Ship Generated Waste Disposal In the Wider Caribbean Region

An Interactive Qualifying Project

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Abstract

Our project provided information on the issue of ship-generated waste in the MARPOL-designated Wider Caribbean Region Special Area and made recommendations based on our findings. Using port-of-call and population statistics, we were able to estimate the amount of ship-generated and municipal waste produced by the region's vessel traffic and Small Island Developing States. We made recommendations on how to create a regional collection system to lessen the burden of ship-generated waste deposited on the islands.

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List of Acronyms

ACS	Association of Caribbean States
CARICOM	Caribbean Community
CARIFORUM	Caribbean Forum
CDB	Caribbean Development Bank
CFR	Code of Federal Regulations
CLIA	Cruise Lines International Association
CPEC	Caribbean Program for Economic Competitiveness
DHS	Department of Homeland Security
EPA	Environmental Protection Agency
FSI	Flag State Implementation, IMO subcommittee on
GEF	Global Environment Facility
ICCL	International Council of Cruise Lines
IEG	Independent Evaluation Group
IMDG	International Maritime Dangerous Goods code
IMO	International Maritime Organization
IQP	Interactive Qualifying Project
MARPOL	International Convention for the Prevention of Pollution from Ships (*Mar*ine *Pol*lution)
MPEC	Marine Environment Protection Committee
NOAA	National Oceanic and Atmospheric Administration
OECS	Organization of Eastern Caribbean States
OPESCA	Organización de Productores de Pesca Industrial
PAWDS	Plasma Arc Waste Destruction System
PMU	Project Management Unit
REMPEC	Regional Marine Pollution Energy Response Center
SBT	Segregated Ballast Tank
SIDS	Small Island Developing State
SOLAS	Safety Of Life At Sea, international convention for
UNEP	United Nations Environment Programme
USCG	United States Coast Guard
WCR	Wider Caribbean Region
WPI	Worcester Polytechnic Institute

Executive Summary

The oceans are used as highways for shipping, tourism, and commerce, transportation, and the world's navies. With the abundance of ships, a tremendous amount of waste is being generated at sea to be disposed of either into the ocean or in ports. It is important for countries and their ports to provide adequate reception facilities for all of the types of ships that frequent those ports. There are international regulations ratified by the signing members of MARPOL (*Mar*ine *Pol*lution), an agreement drafted by the International Convention for the Prevention of Pollution from Ships, which governs what kinds of waste can be discharged overboard and where it can be discharged.

Within the provisions of MARPOL, there are certain regions in the world that are designated as Special Areas. A Special Area is a geographical region where additional restrictions exist that pertain to dumping of a specific class of waste overboard. The Wider Caribbean's status as a Special Area will come into full effect as of May 1, 2011. This particular area has a fragile ecosystem and heavy maritime traffic. When ships offload all of their waste in ports, the region's ports become overburdened. MARPOL classifies ship generated waste into six categories, called annexes, to provide general restrictions for each class of waste. Due to the Wider Caribbean Region's reclassification as a Special Area, Annex V wastes (garbage generated onboard a ship) will no longer be allowed to be dumped overboard within the boundaries of the Wider Caribbean Region or WCR Special Area.

Currently, garbage is allowed to be dumped overboard when a vessel reaches a certain distance from shore as long as the ship follows waste discharge guidelines. When the Special Area designation comes into effect, the ports of the WCR will consequently have to handle a larger amount of waste, since the volume that was once dumped into the sea must now be processed at ports. Many larger nations in the region can already accommodate this increase in ship generated waste. However, this poses a problem for Small Island Developing States (SIDS) because many of

them lack the infrastructure or reception facilities necessary to handle the increase. Limited financial resources limit the ability of small states to construct appropriate facilities. Vessel traffic in the region is one of the primary contributors to the tourist driven economy.

The goal of this project was to quantify the waste production by ships and determine the total burden of ship-generated waste on the SIDS in the WCR. A set of recommendations will be created for improving waste management in the islands. Our project was concerned mostly with the development of a regional collection plan. Through database research, literature review, and calculations, we constructed a database of port of calls in the WCR in order to determine the quantity of garbage waste that can be accepted at the region's ports. This helped to better address the resources and needs of specific ports and identify areas for further data collection. A successful solution to the problem of garbage disposal will allow shipping to continue throughout and beyond the Caribbean's transition to a Special Area with minimal interference with the shipping trade, and with provisions specific to the economic, practical, and environmental needs of the islands and their ports.

1. Introduction

Pollution in the world's oceans causes a significant threat to marine life and is recognized as one of our highest environmental concerns. While there are many sources of marine pollution, one concern is ship-generated waste. Depending on the nature of the waste, international regulations determine whether it may be discharged into the ocean or disposed of on land once the ships come into port. These restrictions apply wherever ships from member countries of MARPOL travel. MARPOL is the primary international treaty governing ship-generated waste. MARPOL is also known as the International Convention for the Prevention of Pollution from Ships. The member states, or those who have signed MARPOL, include 169 countries, which make up the vast majority of the World's shipping tonnage. MARPOL defines several classes of wastes and sets separate requirements for the disposal of each. Of these, garbage (Annex 5) and oil (Annex 1) are the most common and make up the majority of waste tonnage.

The annexes are one major point of focus, while another is different regions of the world. The Caribbean, specifically, presents its own set of challenges. These occur because the Caribbean contains many ports in developing countries, high concentrations of cruise ships, and has an especially sensitive marine ecosystem. The Caribbean, compared to the other parts of the ocean, has many sensitive coral reefs, which can die with subtle changes to the water. These factors make ship-generated waste disposal in the region a complex issue. A specific challenge is that the Wider Caribbean Region will soon be classified as a 'Special Area' under MARPOL, which further restricts the dumping of waste from ships (IMO, 2010). The United States Coast Guard is actively taking part in trying to make this a smooth transition.

While this change recognizes the ecological sensitivity of the region, it puts additional strain on the region's port waste collection infrastructure. This is especially problematic in Small Island Developing States (SIDS), which rely heavily on ships coming into their ports, but lack the means to dispose of the additional waste they bring. Cruise ships, for instance, are critical to the economies of many SIDS, but they also produce significantly more waste than container ships (Cpt. David Condino, personal communication, September 15, 2010). Landfills on many SIDS are not always constructed properly, and more advanced facilities such as incinerators are uncommon (Georges, 2004). Waste can be transported elsewhere, but the costs of such a system have not been examined in detail and the entire process is subject to the Basel Convention (2005). This international convention regulates the shipment of waste internationally. Ideally, either an improvement to port infrastructure or another means of improving waste management in the Caribbean (while maintaining compliance with both MARPOL and the Basel Convention) will need to be implemented.

In the face of such challenges, compliance with MARPOL is not universal. Inadequate reception facilities, high costs of disposal, and other factors may lead some mariners to illegally discharge their ship's waste in the Caribbean's waters. The probability of detecting such illegal dumping in the vastness of the Caribbean is very low, so unless proper disposal is desirable from the mariners' point of view, pollution will continue. Therefore, any proposed solution must be both convenient and cost-effective to provide incentives for compliance.

Some data is available concerning the current states of shipping and waste disposal in the Caribbean, as well as similar transitions to MARPOL Special Areas, as was recently implemented in the Mediterranean Sea. A solution, drawn from this and other information, can take various forms. These may include a business plan to implement upgrades to port infrastructure, reduction of waste on the ships, or proposing a process that allows for a regional collection plan. A successful solution will allow shipping and commerce to continue with minimal hindrance but also result in a significant reduction in the area's marine pollution.

Our team has generated the framework of a plan for the collection of ship generated waste in the Wider Caribbean Region, such that the resulting practices and infrastructure allow compliance with MARPOL regulations. We considered many facets of the problem through the use of tools such as port and municipal waste tables. In addition, we will look into the practices and infrastructure applied to existing Special Areas as applied in similar projects to improve waste management practices and infrastructure. We have provided the United States Coast Guard with not only a description of the plan's major expenses and considerations, but a large set of sources and information that will aid in the finalization and implementation of improvements to ship-generated waste management in the Caribbean.

2. Literature Review and Background

Marine pollution is a problem that affects the entire world and comes from many sources. The kinds of waste generated on ships and dumped into the ocean have had negative impacts on marine environments for decades. Marine pollution negatively affects industries related to the ocean, such as fishing and tourism. Pollutants including oil, chemicals, garbage, sewage, and food waste are all being dumped into the ocean. At the same time, ports find it difficult to manage all of the waste received. This is particularly problematic in regions that are defined by MARPOL as Special Areas, which have stricter requirements on pollution control and that have insufficient infrastructure in port reception facilities to handle the increased amount of waste (D. Condino, personal communication, Sept. 10, 2010). Marine pollution has already affected the marine environment and will continue to do so in the Special Areas unless inexpensive, effective, and efficient waste disposal systems are put in place in affected ports.

In this chapter, we first provide a description of the International Convention for the Prevention of Pollution From Ships (IMO, 2010), also known as MARPOL (*Mar*ine *Pol*lution). Second, we provide a description of the classifications of waste generated on ships. Following that, we provide a summary of the Caribbean and ports, both in Special Areas and elsewhere, which will help to explain and determine what waste reception facilities and infrastructure are necessary for a properly functioning port. Fourth, we provide a description of the kinds of ships that come into Caribbean Special Area ports and the volume and types of waste they generate. Fifth, we provide a summary of the planning, implementation, and review of a previous project used to improve waste reception and management in a region of the Caribbean.

2.1 MARPOL, the Basel Convention, and Marine Regulations

The MARPOL Convention is an international agreement relating to maritime pollution, written in 1973 and modified in 1978 (IMO, 2002). While international environmental law is a broad subject, MARPOL focuses on the regulation of ship generated waste. This agreement continues to be amended to keep up with the evolving shipping industry and to further decrease the impact of pollution on the environment, with new changes and additions being created every few years. Nations that ratify MARPOL are known as 'member countries', and ships sailing under these states make up the vast majority of the world's registered shipping tonnage (IMO, 2002).

2.1.1 MARPOL Definitions and Restrictions

MARPOL categorizes waste into six annexes so restrictions may be placed on groups of materials rather than on specific substances (IMO, 2002). Among member countries, Annexes I and II are required to be ratified, and III, IV, V, and VI are optional and are ratified separately. For each of these categories of wastes, there are specialized treatment, refining, and storage processes both on ships and in port reception facilities. These annexes are as follows:

Annex I: Prevention of Pollution by Oil.

The first annex sets limits on the amount, rate, and distance from land in which oil waste may be released. Annex I waste is not limited to tankers; though these ships produce the largest volumes of it, as other ships produce oily waste and engine sludge as well.

Prevention for oil spills is also included in this annex, with requirements for double hulls and positioning of cargo tanks and segregated ballast tanks in the ships' design. Some tankers operate exclusively between ports with adequate reception facilities, and are able to dispose of all Annex I wastes properly while in port. Some substances, such as vegetable oils, are actually included in Annex II. The discharge of Annex I wastes in Special Areas is prohibited with scarce exceptions.

There are multiple classifications of the oily waste itself, which, in ascending order of oil content, include dirty ballast water, oily bilge water, oily tank washing, oily sludges, and used lubricating oil and fuel residues (IMO, 1999). Wastes with higher oil content by volume are more desirable for recycling, though all wastes must be processed for disposal. For oily ballast water, oily bilge water, and dirty tank washing, the top layer of oil must be separated out from the water before any additional refining. The ships do this using a series of pumps with filters to strain out the oil to less than 10 parts per million (Pollution prevention equipment, 2006). The oily residue is then collected into tanks for offloading at the next port of call. The petrol product from engine sludge is stored similarly in a separate tank to be processed at a port reception facility.

*Annex II: Control of Pollution by Noxious Liquid Substances***.**

The second annex includes a list of specific substances. Depending on their concentrations and other qualities, Annex II substances may be disposed of in reception facilities exclusively, or at least 12 miles from land under certain conditions (IMO, 2002). Annex II pollutants are further sorted into four categories in descending order of potency to the environment, numbered from extreme potency to near harmlessness. Regulation of these substances is also subject to the International Convention for the Safety of Life at Sea (SOLAS).

These noxious liquids predominantly come from chemical tankers and are mostly processed on board the ships. There are chemical processing machines on board that strip the harmful agents from the inert liquids so that they can be condensed and off loaded at the next port (Society of Naval Architects, 1993). Processes vary from substance to substance, and reception facilities for Annex II wastes are not available in most ports.

Annex III: Prevention of Pollution by Harmful Substances in Packaged Form.

This annex's ratification is separate from the remainder of MARPOL, so not all member countries are subject to it. However, Annex III goods are also subject to much of the International Maritime Dangerous Goods (IMDG) Code, which itself identifies which substances fall under Annex III (IMO, 2002). It is more concerned with packing, labeling, and documentation than are the other annexes.

Annex IV: Prevention of Pollution by Sewage from Ships.

This annex requires ships to have either a sewage treatment facility, a disinfecting system, or a sewage holding tank (IMO, 2002). Untreated sewage must be discharged at a distance of at least 12 nautical miles from shore, however, if the ship has a sewage treatment facility it may discharge waste at least3 nautical miles from shore.

Sewage is a waste that is produced on all ships in varying quantities. This type of waste controlled under Annex IV can be broken down into grey water and black water. The grey water is waste water from showers, dish washing, and laundry, while black water is waste produced from toilets and medical waste. One method with which these two types can be processed is by using a bio-membrane reactor. This reactor has active agents inside that eat away at the harmful bacteria, which then are filtered out using a membrane (Benson, Caplan, & Jacobs, 1999). This process produces semi-clean water that can be used in technical processes such as engine cooling, offloaded at port reception facilities, or discharged overboard.

Annex V: Prevention of Pollution by Garbage from Ships.

This annex sets restrictions on the handling of garbage, including all food, domestic, and operational waste (IMO, 2002). The annex completely prohibits the dumping of plastics at sea. It is further divided into six categories, including: (1) plastic, (2) floating wrapping, lining or packaging material, (3) ground paper products, rags, glass, metal, bottles, (4) paper products, rags, glass, metal, bottles and crockery, (5) food waste, and (6) incinerator ash (Carpenter & MacGill, 2003, p.28). The Caribbean was designated a Special Area with restrictions on Annex V due to its heavy maritime traffic, sensitive marine ecosystem, and the nature of the currents through the region. While it is optional, most member nations are signatories to Annex V, and it contains some additional provisions for enforcement. For instance, a Garbage Record Book must be kept on ships of sufficient size, and procedures for the collection and disposal of garbage must be compiled in writing in the ship's Garbage Management Plan. Requirements for shipboard incinerators are also included. Governments that ratify Annex V must also ensure garbage reception facilities are provided by ports.

Some waste can be disposed of overboard so long as it is outside a certain distance from shore and outside of a Special Area (IMO, 2002) (See Appendix P for distances). The restrictions on the dumping of garbage prohibit the discharging of plastics anywhere on the ocean. Other restrictions on dumping locations can be found in Appendix C. These regulations exist for important reasons. For instance, some material that is dumped overboard can take up to 450 years to degrade (see Appendix C). As a Special Area, waste that was previously disposed of in this manner will now be required to be collected in port reception facilities.

Annex VI: Prevention of Air Pollution from Ships

Air pollutants of primary concern are ozone depleting substances, sulfur oxides, and nitrogen oxides (IMO, 2002). Most Annex VI pollutants originate in the ship's engines.

2.1.2 MARPOL Special Areas

The concept of a 'Special Area', a geographic region with stricter restrictions relating to one or more of MARPOL's Annexes, was introduced in 1973 (IMO, 2002). A Special Area is defined as "a sea area where, for recognized technical reasons in relation to its oceanographic and ecological condition and to the particular character of its traffic, the adoption of special mandatory methods for the prevention of sea pollution by garbage is required" (UNEP, 2005, p.50). This means that considerations related to the environment and maritime traffic in the Caribbean have led the IMO to take action in further reducing the amount of garbage in Special Areas. In 1991, the Wider Caribbean was added as a Special Area under Annex V, effective May 1, 2011, due to its sensitive marine ecosystem and the heavy traffic in the region (IMO, 2002). While compliance with the Special Area's requirements will allow for a healthier marine ecosystem, adequate port reception facilities are needed at the region's ports for compliance with the terms of the treaty to be possible. .

Implementation of a Special Area requires that a sufficient number of member countries in the affected region report that adequate facilities are available. While this provision assumes that most countries have the facilities already, some do not. For these ports, the IMO offers technical assistance in the development of improved reception facilities. Advisory assistance and other resources may also be available from other parties of the convention, as a Special Area transition is considered to be a *concerted effort* by all affected governments in the Special Area (IMO, 1999).

2.1.3 MARPOL and the Role of the United States Coast Guard

MARPOL is a treaty defining strict regulations for international shipping of waste with regards to the member countries. There are regulations stipulating the required documentation of shipments from one party nation to another. Nations not signed into the treaty could have their shipments of waste deemed illegal and may face legal consequences in the member nations they travel to (IMO, 2002). MARPOL is an international treaty, so enforcement is left to the governments of member countries. In the United States, the Coast Guard can create policies related to many areas of maritime practice and can enforce them in US territorial waters. Representatives of the Coast Guard also attend international conferences related to Marine Pollution, and participate in discussion relevant to the development of new national and international policies (D. Condino, personal communication, Sept. 10, 2010).

The Coast Guard defines domestic regulations with contributions to the Code of Federal Regulations (CFR). The office that is directly related to the issue included in the volume of the CFR is responsible for creating and updating it. For CFR 33, Navigation and Navigable Waters, this agency is the United States Coast Guard.

In CFR 33, Subchapter O, part 151, pollution information, processes and regulations are stated for the topics of Vessels Carrying Oil, Noxious Liquid Substances, Garbage, Municipal or Commercial Waste, and Ballast Water (Code of Federal Regulations 33, 1999). This volume includes the details of the Act to Prevent Pollution from Ships presented as a set of regulations, and in this way is the implementation of MARPOL in the United States. The section elaborates on enforcement, information recording, reporting, as well as its restrictions in the designated Special Areas (Code of Federal Regulations 33, 1999).

USCG-led initiatives in CFR 33 and elsewhere also set an example for future international standards. Demonstration of effective practices in the United States can lead to their adoption in other countries (NRC, 2009).

2.1.4 The Basel Convention

The Basel Convention (2002) is a policy that was created during a treaty negotiation under the guidance of the United Nations. Its intent is to prevent nations from transporting waste to other nations for disposal if this transfer will result in the waste being disposed of improperly. The Basel Convention is separate from MARPOL, which deals with waste disposal rather than its transport.

The Basel Convention allows for international shipments of waste under very specific conditions and documentation. Most of the Basel Convention's restrictions apply to hazardous waste, which it defines in several annexes, using a system of classification different from the one MARPOL uses (UNEP, 2010). For the purpose of the convention, *waste* is a substance that is disposed of according to national law or is listed specifically in the convention. *Hazardous waste* is waste that fits one of several definitions in the Basel Convention or is defined as hazardous waste by the domestic laws of the waste importer, exporter, or domestic country of the transporting service. Since the Basel Convention's classifications of waste are different from MARPOL's and those of individual countries, it is possible that garbage may contain substances that are classified as hazardous wastes under the Basel Convention.

A solution proposed by the USCG defined a regional collection plan that would place the responsibility of waste disposal at a regional level rather than at a national level (D. Condino, personal communication, September 10, 2010). Although this plan involves the shipment of waste internationally (and thus would be subject to restrictions in the Basel Convention), our project will assume compliance with the Basel Convention and instead focus on legal and technical challenges related to a regional collection plan.

2.2 Ports and Port Reception Facilities

Reducing marine pollution will require cost-effective ways for ships and shipping companies to unload their waste efficiently, so ships are both willing and able to use the port facilities instead of discharging while at sea. There are many ports around the world that have a well-established infrastructure and procedure for disposing of ship generated waste. Studying these ports and their inner workings may lead to a solution to the proportionally large volume of waste that cannot be processed in certain ports. Small Island Developing States (SIDS) in the Special Areas defined by MARPOL are at the center of this problem.

2.2.1 Successful waste and pollution management strategies

A port that has a successful waste management policy and practice is able to process all kinds of waste that a ship may bring in as long as due notice is given to the port. However, not all ports do actually provide reception facilities for the kinds of waste they receive. Carpenter and McGill (2003) completed a study about portside reception facilities in ports in the North Sea. The results of the 66-port survey were that most ports offered some reception facilities. For Annex I, or oil based waste, 47 ports offered facilities for lubricating oil, 42 covered oil sludge, 43 covered oily bilge water, 28 covered dirty ballast water, and 34 offered oily tank washing facilities. This study indicates that over half of the ports surveyed offer some facilities for disposing of petroleum-based waste, often with provisions for multiple kinds of waste handling. For Annex II, noxious liquids, only 27 out of 66 ports could receive chemical waste, while 38 could not support any chemical tanker reception. Fewer than half of the ports provided facilities for Annex V for all varieties of trash, but only one supplied facilities for only one type of trash. Overall, these data indicate that there are many ports that do not accommodate all types of waste, but there are surrounding ports that may offer the remainder of the facilities needed. This model of having specific facilities unavailable at a certain port but available at a nearby port allows for functionality in the North Sea without excessive infrastructure. In some cases, this may also require waste disposal at ports where ships did not originally intend on visiting.

In the Caribbean, there are several initiatives that focus on cleanup and public awareness (UNEP, 2009). Many states participate in the International Coastal Cleanup (ICC) program, which collects data about marine litter and coordinates local communities in waste cleanup. Awareness for solid waste management and litter prevention take place in many separate initiatives. Since much of the waste analyzed on coastlines comes from individuals, public awareness of clean programs and practices is seen as very important.

2.2.2 Adequacy within a port

For a port to fit the IMO's definition of adequacy, there are some requirements a port must follow. Advanced planning by both the harbor and the crew member responsible for waste management is key to the success of a well-run port waste facility (IMO, 2002). It is the job of the crew member is to communicate with the port's waste management personnel to express the ship's specific needs for waste removal once in port. The information transferred should be types of waste, i.e. Annex I-VI, and the quantity to be removed. Paperwork filled out and sent to the port includes a Standardized Advanced Notification Form, which defines the waste reception needs of the ship in a manner defined by the IMO.

Overall, Ball (1999, p. 38) lists five major considerations for collection facility adequacy:

1. Ports should cater to all types of waste landed at a port;
2. Reception facilities should be conveniently located;
3. Facilities should be easy to use;
4. Facilities' use should provide a cost incentive;
5. Periodic inspections should be made to ensure adequacy.

Once the waste is brought to the port, there are a number of requirements for an adequate port reception facility. The reception facility must be able to accommodate Annex V, or garbage removal, in its segregated form, which means that the port should have a way to dispose/recycle each of the six types of garbage defined by the IMO. In discharging petroleum-based products, or Annex I wastes, the port should have the fitting for the standard connection arrangement to the waste system of the ship, as well as storage and processing equipment for oily wastes. Ports used for depositing other annexes must have facilities for those kinds of wastes, though Annexes I and V are the most common. In addition to catering to the type and volume of wastes brought to these facilities, ports should also make an effort to ensure that the reception facilities are convenient and provide cost incentives for their use. Inexpensive or mandatory payment and minimizing delays can act as these incentives. Periodic inspections should also occur to maintain compliance with MARPOL. While an adequate facility is defined by the IMO, it is the job of individual countries to enforce requirements related to adequacy. These specifications for waste offloading are generalized for all ports and should be applied by SIDS in any additions to their port reception facilities (IMO, 1999).

David Condino (personal communication, October 1, 2010) notes that the volume of this waste is also important. A port that occasionally hosts cruise ships but can only provide accommodation for a portion of their waste is not adequate (IMO, 2002). As ships operate on tight schedules, a facility also must not to cause undue delay in the removal of these wastes. A modern and efficient set of waste reception equipment will go unused if it is in a remote part of the port or is not operational for the same hours as is the remainder of the port. Another major requirement is that ships must give advanced notice of their waste disposal needs. This allows the ports time to prepare, though it is hard for smaller ports to monitor for this advanced notice on a 24-hour schedule.

2.3 Adequacy at a Regional Level

The requirements in the previous section define adequacy within a single port. However, a country with multiple ports or a set of countries in a contractual agreement can provide similar services at a regional level with less overall infrastructure. Since the addition of a Special Area requires existing adequate port reception facilities in most (but not all) countries with ports in the

Special Area before the Special area can come into effect, regional adequacy allows that minority of ports be compliant at the regional level.

Regional infrastructure uses fewer separate pieces of infrastructure. However, regional adequacy usually means there is a heavier burden on the ports that do have adequate reception facilities, and may act as an inconvenience to ships' schedules (IMO, 1999). Regional *collection* may also require that there is a means of transporting waste between ports.

2.4 The Wider Caribbean Region

The uniqueness of the Caribbean's geography, economy, governments, and environment means that there is a special set of considerations that must be applied to any project in the region. These considerations will be in formulating any plan to improve ship-generated waste collection in the Wider Caribbean Region (WCR).

2.4.1 Geography

The Wider Caribbean Region (WCR) (figure 1) includes the Gulf of Mexico, the Caribbean Sea, a section of the Atlantic Ocean between the Caribbean Sea and a border defined by the International Maritime Organization, as well as all bays and seas within this boundary (Code of Federal Regulations 33, 1999). The mainland countries of the United States, Mexico, Belize, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Venezuela, Guyana, Suriname, and French Guyana all border the WCR and have ports on its waters(Hanratty & Meditz, 1987). Below a map depicts the boundaries of the WCR Special Area.

Figure 1 Boundaries of the Special Area

Modified from *Central America and the Caribbean* (2010).

The island countries and territories in this region are the primary focus of the project. With the abundance of islands in the WCR, most countries are made up of multiple islands, which vary in size from uninhabited rocks to Cuba, which is home to millions of people. Most of the smaller islands can be found in the Greater and Lesser Antilles in the southern and eastern WCR (e.g., Netherlands Antilles, British Virgin Islands), and in the northeastern Lucayan Archipelago (i.e., Bahamas, Turks and Caicos) (Hanratty & Meditz, 1987).

2.4.2 Economy

Since the 1950's, tourism has become a dominant industry in the Caribbean. On the US Virgin Islands, for example, tourism makes up over 70% of the islands' jobs and GDP. Much of the tourism comes from the United States, so fluctuations in the US economy tend to affect the

Caribbean as well. Construction is also an important industry, as tourism requires extensive infrastructure in roads, ports, hotels, airports, and attractions (Caribbean Guide, 2010).

Agriculture has been important to Caribbean islands since colonial times. Sugar, bananas, and eggplant are common export crops, and some others are grown for local consumption. Fishing is another common local food source (Hanratty & Meditz, 1987).

Industry also has a presence on Caribbean islands, though industry generally ranks behind tourism in terms of profitability and widespread use. For instance, St. Croix and Aruba both have major oil refineries, and Barbados and Antigua both have factories for electronic components. Rum is a significant export as well. Some islands have mines for resources such as asphalt and bauxite, though overall the Caribbean has very limited natural resources (Hanratty & Meditz, 1987).

Due to the region's close ties to the United States through the tourism industry and trade, many countries tie the value of their currency to the US dollar at a fixed rate (Caribbean Guide, 2010).

2.4.3 Government

In colonial times, the Caribbean was under the control of European powers, with each possession being considered a territory or similar possession of the colonizing country. In these cases, there was a local government to handle local affairs, but many of the laws come from the country in possession of the territory. Many territories have gained independence, and the modern Caribbean is a mixture of independent states and territories which maintain local governments but are still owned by foreign nations. Currently, the United States, United Kingdom, France, and the Netherlands still maintain island possessions in the WCR (Hanratty & Meditz, 1987).

The countries in the WCR which gain independence tend to have small democratic governments. Historically, a number of islands in the region have faced occasional political instability. Many islands form regional agreements for trade and international representation (Hanratty & Meditz, 1987) (See Appendix J for regional agreements by country). Free trade exists among most Caribbean nations.

2.4.4 Environment

In the WCR, the climate is tropical, with generally warm temperatures and moderate precipitation. The Caribbean is prone to hurricanes, with the active season stretching from June to November, although these storms are uncommon in the far eastern and far southern parts of the Caribbean. Landscapes of the islands vary, ranging from volcanic formations to grassy hills to dense rainforest. While much of the coastline is made up of sandy beaches, many islands have natural harbors as well (Hanratty & Meditz, 1987).

In the Caribbean and the Gulf Coast area there are many currents and environmental factors that affect how marine debris travels in the water. There is an influx of ocean water from the Atlantic Ocean that remains in the Gulf Coast region for a period of one to two years, with only minor outflow. The outflow is inhibited by loop currents as well as wind and weather factors. These currents and outside factors tend to concentrate the marine debris in the sensitive Caribbean area where there are many species of endangered whales, birds, sea turtles, and vulnerable coral reefs (MEPC, 2010).

2.4.5 Ports in SIDS of the Wider Caribbean Region

The Caribbean Sea contains the largest concentration of UN-designated Small Island Developing States on Earth (Andrade, 2010) (See Figure 2). The number of SIDS and maritime traffic complicate the improvement of port reception facilities in the WCR in preparation for the region's reclassification as a Special Area.

Figure 2: SIDS in the WCR

Modified from *Central America and the Caribbean (2010)*

The marine pollution problem in the WCR may continue after the region's classification changes to a Special Area. This may be due of the inadequacies of waste reception facilities on many of the islands, which could possibly act as an incentive for ship operators to discharge their waste into the ocean. The majority of the limitations result from the lack of infrastructure in reception facilities and the lack of financial and governing body support for improving those facilities. Many nations with ports on the Caribbean are SIDS, but these nations vary significantly in terms of resources, maritime traffic, and current infrastructure. Most of the countries only fulfill the minimum requirement for reception facilities to incoming ships (IMO, 2002). With high concentrations of cruise ships and other vessels, the WCR has one of the highest concentrations of maritime traffic in the world (Andrade 2010). For a table of port reception facilities by country, see Appendix D.

2.5 Current Waste Disposal Considerations

A number of methods exist for disposing of different types of waste. While port reception facilities do require specialized equipment to unload waste from ships, it is important to also consider how waste is dealt with on land. Ship generated waste that is unloaded at ports must be processed on land, and analyzing these methods may provide suggestions as to how waste can be dealt with at sea or how improvements may be made to port reception facilities. In each area, it is important to consider both startup and running costs (and potentially profits), as these will be important factors in their applicability to SIDS.

2.5.1 Land-Based Disposal

A majority of waste generated on land goes to landfills. While a landfill may seem a simple piece of infrastructure, a successful one requires numerous, precisely layered arrangements of materials both above and below the volume of waste to minimize runoff and smell and to reduce the risk of fire or explosions. This infrastructure is costly when properly constructed. For instance, a single liner layer (of which there are about a dozen types in a typical landfill) can cost as much as $53,000 per acre (Daniel & Koerner, 1995). Landfills in the United States also periodically require specialized personnel for inspections.

While landfills are the standard method for containing non-recoverable waste, composting and recycling allow for a more renewable alternative. A 1990 assessment of American waste disposal showed that a third of material by weight was either composted or recycled (Daniel & Koerner, 1995). Incineration offers an alternative. Nearly a third of non-recycled and non-composted waste is listed as ‘combustion with energy recovery’ (Daniel & Koerner, p. 36).

2.5.2 Waste Reception Facilities

Waste reception facilities vary in size and complexity. In very small ports, waste may be removed by hand, while major ports may have elaborate, efficient, and expensive automated systems. A marina may contain a “skip” (a large open container) for waste disposal that is simply emptied periodically (Ball, 1999). Larger facilities contain elaborate systems for large scale waste disposal, and ports designed to accommodate oil and chemical tankers have specialized equipment to manage those kinds of waste.

The different varieties of equipment used for unloading waste vary with scale and the particular type of waste being removed (see 2.1.1, MARPOL Definitions and Restrictions, and Appendix B). In terms of scale, larger facilities tend to have mobile features like road tankers, barges, and similar land based vehicles to go to where the ship is docked, and often to transport the waste to a storage facility (Ball, 1999). The limited capacity of most mobile devices also means multiple trips may be required for larger vessels, which takes more time and has a larger risk of spills (D. Condino, personal communication, October 1, 2010). Stationary infrastructure can be justified when it is positioned conveniently, the overall system is more efficient, or the volume of waste it is intended to remove is impractical for a mobile system. Several ports on the Baltic Sea, for instance, connect ships directly to the local sewer system for gray water and black water (types of sewage), which has tremendous capacity and a minimal number of connections (one), minimizing the risk of a spill. Annex I and 5 waste disposal methods are described below, as these make up the larger volumes of waste than the other Annexes and are of the most concern to the WCR.

Annex I Waste Disposal

Disposal and treatment facilities are used for many types of waste. There are procedures used for separating oil from water and refining it for possible future use. Oily ship-generated waste disposal in a port reception facility consists of three major steps, which are applicable to most kinds of oily waste. Ballast water uses a similar process, but for volume reasons requires a much larger facility.

The primary treatment, gravity separation, is a mechanical separation by settling, as most of the water and oil will separate if the mixture is not agitated. The layer of oil on top of the tank is then removed by skimming or overflow, though the water can also be drained from below. Primary treatment can produce an effluent oil concentration of 50-200 ppm (IMO, 1999).

Secondary treatment is a chemical process which removes emulsions that could not be treated by gravity separation. First, a coagulation tank adds coagulants (typically iron and aluminum salts and charged polymers) to break the emulsions. Next, the volume containing the coagulated particles is transferred to a flocculating tank. Flocculants cause the coagulated particles to congregate into larger chunks. These chunks, or 'flocs', require closely regulated pH, agitation, and chemical dosing to form properly. A flotation tank then adds bubbles to the wastewater, which push the flocculated particles to the surface where they can be collected with a skimmer. A filter then removes particles not caught by the previous methods (IMO, 1999). Post-filtration wastewater can have an effluent oil concentration between 5 and 20ppm, depending on the quality of the floccuation. Alternatively, hydrocyclones and centrifuges can be used for the separation of wastewater's contents by density.

Annex I waste containing additives or requiring further cleaning can go through tertiary treatment, which is biological in nature. The wastewater is sent through a tank with activated sludge which contains microorganisms capable of degrading certain substances remaining in the wastewater. Tertiary can produce water with less than 1ppm of effluent oil, but biological treatment tends to be a more refined process requiring experienced operators (IMO, 1999).

Facilities without ballast water processing or tertiary treatment can be relatively inexpensive for small ports. A mobile or stationary storage tank allows the waste to be processed in batches appropriate to the port, and secondary treatment processes can be selected based on the port's resources (IMO, 1999). Alternatively, having only storage tanks within a port allows waste to be transported off-site to a central processing facility.

Depending on the quality and quantity of Annex I wastes received and processed in a port, there may be several options available for the recycling of oily wastes. It may be used as fuel, be it in local industry such as cement production, furnaces, the port's bunker or as power for the waste processing equipment itself. Waste oil is often added to existing fuel for these purposes. Redistillation is possible if there are appropriate facilities available nearby (IMO, 1999). For these facilities to accept the waste, the waste must be relatively free of contaminants or water. Less refined oil may require that compensation for the refinery, though higher quality material may act as a source of revenue.

Annex V Waste Disposal

A port receiving Annex V wastes is typically more focused on preparing the wastes for transport rather than processing on-site. The primary concerns for garbage collection are capacity and transportability (IMO, 1999).

Capacity is a balance between practical considerations and available space. Small receptacles are impractical for larger amounts of waste, but these receptacles can be easily stored and moved within a small port. Larger receptacles can be less mobile, but can handle bulkier garbage and have a greater individual capacity. The overall capacity of a port, regardless of the containers it uses, should reflect its emptying schedule. For instance, a more frequent emptying schedule requires more resources in vehicles and labor. Annex V storage at the port can be smaller and there are fewer health concerns related to storing garbage over a longer period. A port may invest in a compactor or incinerator to reduce the amount of space its stored garbage takes up.

Larger receptacles that are moved around the port (and in some cases, onto the ships) need to be compatible with the port's cranes and forklifts. In some cases mobile receptacles such as trucks and barges can be used to move directly to the ship and can be used to transport the waste to its final disposal or processing (IMO,1999).

Some types of Annex V wastes require special considerations. Many countries require special procedures for medical or biohazard waste. Recyclables must be received separately if a recycling center is accessible from the port (IMO, 1999). Many ships segregate different types of garbage as well. Provided there are means of processing these kinds of waste separately, a port may provide segregated storage for these wastes (D. Condino, personal communication, Oct. 27, 2010).

Annex V includes a number of recyclable materials. These offer local benefits through the saving of raw materials and energy, minimizing negative effects on the environment, and through revenue from the resale of recycled materials. Metal, paper, glass, and plastics can be recycled as materials in new products. Organic wastes can be composted for local agriculture (IMO, 2009). The expenses related to recycling mean that recycling will occur almost exclusively on islands that already have recycling centers, as a port's recyclables alone cannot justify the construction of a recycling facility.

2.5.3 Waste Treatment On-Board Ships

The environment of a ship provides practical limitations to waste processing, and MARPOL restricts some of these processes further. Nevertheless, ships still have several methods of waste processing available to them while at sea (Butt, 2007). Several methods are shown in Table 2.

Table 1 Methods of Waste Reduction

Compactors	Reduces the volume of solid waste at sea. Since most waste is measured by weight, this is primarily a practical consideration for ships
Comminuters	Shreds food scraps into smaller particles that can be discharged overboard
Pulpers	Shreds and homogenizes paper and cardboard waste for disposal at sea
PAWDS	Plasma Arc Waste Destruction Systems, uses plasma energy to destroy combustible waste. New, effective technology, but with extensive retrofit costs
Shredders	Grinds plastic, metal, glass, and bone for more compact storage
Incinerators	Burns non-recyclable Annex V waste. Ash is collected for disposal at a port

Many of these practices are not applicable to an Annex V Special Area, and these wastes must be disposed of in port or by one of the above methods at sea. Adding new equipment to existing ships is difficult for financial reasons. However, Butt (2007) suggests ship owners and operators can reduce the quantity of waste on their ships by methods such as selecting provisions with more environmentally friendly packaging. Currently, incineration on board is more common than recycling due to the lack of recycling facilities at port reception facilities.

2.6 Ships in the Caribbean

The Caribbean area is home to many types of ships coming from many places worldwide. MARPOL considers very specific parameters relating to ships in its requirements (IMO, 2002).

Different types of ships are likely to be sources of different categories and quantities of pollution. Below, we describe the major types of shipping present in the Caribbean.

Because the Caribbean is a highly traveled vacation destination, there are many cruise liners that use the ports of the SIDS on a regular basis. Due to the large number of people on board in comparison to other ships of similar size, Cruise ships make up less than 1% of the global merchant fleet, but are responsible for 25% of all waste generated by merchant vessels in the Caribbean (Butt, 2007, p. 1). Although the cruise ships' waste streams are controlled by many regulations including the International Council of Cruise Lines (ICCL), they still generate large amounts of waste that some small islands do not have the infrastructure or land resources to be able to handle.

Specific requirements for oil-carrying vessels are outlined in MARPOL Annex I (IMO, 2002). The variety of oil containing wastes (oily bilge water, crude oil, etc.) present on these vessels means there must be much more extensive waste reception facilities for ports designed to accept oil tankers (Carpenter and MacGill, 2003).

2.6.1 Barges

A barge is a type of craft whose main purpose is for transport of materials. Barges typically have no means of self-propulsion and require an additional vessel for movement. A tug boat usually provides the power for motion and either pushes the barge or uses towlines, also known as hawsers, to tow the barge. Some barges are fitted with a notch in the rear of the boat where the tug boat can fit into, allowing more control of the vessel it is transporting. These are known as Articulated Tug Barges (The American Waterways Operators, 2010). Some barges are fitted with engines and can move under their own power. Barges usually have a flat bottom and are used on rivers and canals, though designs with V-hulls are made and can be used to travel on the open ocean as well, which make it applicable to a regional collection plan in the WCR.

The reason barges are often used for transport of materials is because of their ability to move large quantities of volume and weight. Being able to move such large amounts with one vessel, as compared to many smaller vessels or other methods of transportation, means costs are reduced and emissions to the atmosphere are lowered as well (The American Waterways Operators, 2010). Thus, the use of barges, and shipping in general, is a cheaper and more environmentally friendly means of transportation. Barges have been used to move many types of materials ranging from vehicles and containers to oil and garbage. Though a barge is very simple, its versatility and expense make it ideal in its role.

2.6.2 Marine Traffic

In addition to cruise ships, barges, and tanker ships, there are many commercial vessels that frequent ports of SIDS. These ships include large container ships to transport the resources made on the islands to markets around the world and to import the necessary goods needed for life on the islands. These ships generate waste under all of the annexes of MARPOL, I-VI, and share many of the same general considerations in terms of port reception facilities.

The overall quantity of maritime traffic in the Caribbean is very significant. The Association of Caribbean States (2002) estimates that 63,000 ship calls are made in the regional annually. Each year, those ships deposit 82,000 tons of garbage into port reception facilities.

2.7 The World Bank and the Global Environment Facility

With Annex V being adopted by MARPOL in 1991, the Global Environment Facility (GEF) decided to conduct a project to improve waste management in a region of the Caribbean. The GEF is a partnership of ten private international companies (See Appendix F for a list of partners) that provide grants to developing countries and countries with economies in transition. (Global

Environmental Facility, 2010) These grants are for projects dealing with global environmental issues. The World Bank, as one of the ten member agencies of the GEF, took the lead on this project and provided the personnel for project leadership. The project has official reports in three parts: a proposal, an implementation plan and an evaluation. These were created during those respective stages of the project, and together provide a comprehensive documentation of a waste management plan in the Caribbean.

2.7.1 World Bank Project Research Proposal

The proposal portion of the project described how the group originally planned on attacking the problem of land based and ship generated waste management. This initiative was sponsored by the World Bank, the IMO, and other partners in a coordinated effort. In total the project had a budget of $5.5 million to allocate for various tasks (World Bank, 1994).

The purpose of this project was to supply the local governments of the six Caribbean SIDS with information on legal, technical, and institutional tools necessary for the implementation of a waste management plan. Additionally, this collection of information from the region was used to determine how the monetary resources of the World Bank could be used best to help the region comply with the regulations of MARPOL (World Bank, 1994). The regional consensus and acceptance of MARPOL was the stepping stone to the second phase of the project, the implementation of resources. The allocation of international and local funds supported a regional legal framework for the regulation of ship waste, waste management plans, processing and storage facilities and a public awareness plan (World Bank, 1994).

The World Bank project was to be coordinated by a group of three consultants hired by the World Bank, who liaised with the six countries in the WCR. Over a span of three years, the consultants were responsible for coordinating with the national governments within the Caribbean region, with a common goal of increasing awareness and the ratification and implementation of MARPOL. These titles of the consultants included a technical consultant, a legal consultant and a project coordinator (World Bank, 1994).

The responsibilities of the technical consultant included acting as a liaison among national governments and regional officials from the IMO, ensuring that adequate reception facilities are in place at the ports, as well as making a comprehensive list of port reception facilities. Several courses were run by the technical consultant on various topics including legislation, waste reduction and the effectiveness of the project. Another responsibility was to create methods for providing technical assistance to nations and port authorities with respect to MARPOL regulations and port reception facilities (World Bank, 1994).

Second, the legal consultant's responsibility was to identify the Caribbean as a legally defined Special Area and write any legislation necessary to make the transition. The legal consultant also helped build local teams of lawyers in each nation, assess the efforts of nations in the enforcement of MARPOL, helped in the public awareness campaign as well many other tasks (World Bank 1994).

Lastly, the project coordinator was responsible for the overall management of the World Bank initiative in the WCR. He or she had a hand in selecting this legal consultant and the technical consultant. The coordinator was also to liaise with the national government s and IMO advisors. In order to gain interest in the initiative the project coordinator gave briefings to GEF members, national governments, potential donors and non-governmental agencies (World Bank, 1994).

It was envisioned that because the project was addressed on a national and regional level, incorporating legal and logistical factors, that the project would succeed in instating permanent implementation, legislation, and enforcement of MARPOL.

2.7.2 World Bank Implementation Plan

The implementation plan, completed in 1995, was part two of the World Bank's initiative to assist the Wider Caribbean Region in its efforts to become a Special Area. The information necessary to complete an implementation plan came from the methods described in the research proposal. The report described in great detail the World Bank's objectives, and exactly how they planned to achieve those objectives. Multiple objectives were created, but can be categorized into two basic objectives: to reduce marine pollution from ship-generated waste and to establish management plans to insure the correct disposal of the waste.

Six countries were deemed appropriate to be a part of this project based on their relative infrastructure, facilities, and geographical locations. These countries were Antigua and Barbuda, The Commonwealth of Dominica, Grenada, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines. Their lack of infrastructure resulted in poor ship-generated waste reception facilities. Therefore, in order to reduce marine pollution, the first objective in the project, the World Bank decided to provide ports in each country with reception facility equipment. The quantity and cost of the types equipment for each port had already been determined and was included in this report. (See Appendix G for example). Each port would receive money through docking fees, government contributions, tipping fees, etc. Labor costs and other recurrent costs were also included for the purpose of doing a cost benefit analysis. The cost benefit analysis was conducted to show that each port should receive profits for the first five years after facility implementation. (See Appendix H for full analysis).

The management of individual ports was subjected to the respective port authority, as was the usual case. To assist in the individual port management efforts, a regional Project Management Unit (PMU) was implemented. This unit would consist of a project manager, financial manager, and support staff. The purpose of the PMU was for "project management, training and education, establishments of common legal frameworks, developing recycling opportunities for solid waste, assistance with enforcement of MARPOL 73/78 Convention, and public awareness," (World Bank. 1995, pg. 10).

2.7.3 Project Evaluation

A project evaluation was completed by the World Bank's Independent Evaluation Group, or IEG. The results of the actions defined in the proposals were evaluated in terms of relevance, efficacy, and efficiency. Using these criteria, the project was considered to have been well thought out and implemented overall. There were, however, several flaws that inhibited its permanent effectiveness. Most of the flaws were management issues that arose between the six nations involved.

First, there was no forum that these nations could use to coordinate their efforts. As a result of this, another issue arose, which was the lack of an entity, convention, or a coordinating body where the nations could bring up issues that might occur (Chakrapani & Le Libman, 2006).

The IEG also faulted the project's underestimates of costs (Appendix I). These underestimates in project costs arose in large part because of underestimations of waste management plans, more specifically, landfills (Chakrapani & Le Libman, 2006).

Though large problems were found, the IEG found that the project was successful in completing most of its main objectives. Overall, this project was supposed to minimize marine pollution and public health risks that arise from it (Chakrapani & Le Libman, 2006). The project failed to implement methods to measure these changes and therefore could not be reported on and evaluated quantitatively.

2.8 Summary

It is important to consider the ways in which MARPOL regulates ship generated waste, as this is central to the problems associated with the Wider Caribbean's transition to a Special Area. MARPOL, however, is just the governing treaty. Practices on ships, in port waste reception facilities, and on land dictate which options are available for waste disposal. Ecological and economic considerations unique to the region and to individual islands place local limitations on these options. Looking at these parameters in the Caribbean and elsewhere will give insight into how solutions to similar problems can be applied here. Based on this collection of information, it will be useful to consider the preferences and opinions of individual stakeholders and gain a deeper understanding of factors unique to individual islands in our solution.

3.0 Methodology

The goal of this project was to present recommendations to the Coast Guard for the implementation of a regional ship-generated waste collection plan in the Wider Caribbean Region based on ship and municipal waste generation data. In order to achieve this goal, we needed to complete three major objectives. These objectives were to:

1. Quantify the waste generation of ships, countries and territories in the Wider Caribbean Region.
2. Compare municipal and ship-generated waste
3. Propose recommendations for a barge-based regional collection plan

A variety of methods was used to complete each of these objectives. These objectives were completed in order, since the each objective's results were necessary for the methods of the following objective.

3.1 Quantify Ship-Generated Waste

A quantitative assessment of waste generation by ships in the WCR is essential to understanding how much waste port reception facilities handle. Using published reports and averages, we estimated the waste generated for ships, ports, and countries.

3.1.1 Determine Ship Traffic by Country or Individual Port.

In order to establish how much waste is generated by ships, it was necessary to categorize the ships that frequent each port by type and quantity. First, a list of ports in all of the Wider Caribbean Region was collected through the use of online databases that provided general information about each port, including size and functional classification (e.g., harbor, seaport, jetty) of the port. Once the list of ports was complete, we researched vessel traffic information for individual ports and countries. Typical sources of information for this included the port authority webpage of the port or national government. In most cases where the information was available, the port authority supplied a statistics page about ship traffic in tonnage and or calls of ships over a time interval. After all the port research was complete, we were able to categorize a portion of the ship traffic by country, type of ship, and port. However, for many ports, information was incomplete or unavailable. Accommodations for incomplete or missing data can be found in section 4.1.2.

3.1.2 Estimate Ship Waste Generation

The amount of Annex V waste generated on a ship is related to length of voyage and the amount of people onboard. We determined the average number of crew and passengers for each type of ship, which included cruise ships, cargo ships, container ships, and tanker ships. We also considered the fact that cruise ship passengers tend to generate more waste than the crew or crews of other types of ships. The REMPEC Model (see below) accounts for this and generalizes the average to everyone on board the cruise vessel, both passenger and crew. The standard values used to calculate estimates for ship-generated waste can be seen in table 2, and have been described in Appendix Q. The standards are all averages and do not account for any variability in vessel, passenger, or voyage differences.

Table 2 Standard Values Used in Calculations

7 day travel basis
28 persons on a non-cruise ship vessel
3500 persons on a cruise ship vessel
42 gallons of fuel/ barrel
200 barrels of fuel/ day
2 kg of waste/day/person on non-cruise ship vessel
3 kg of waste/day/person on cruise ship vessel 11 kg maintenance waste/vessel/day

The Regional Marine Pollution Energy Response Center (REMPEC) model represents the total garbage received over a period of time as the sum of several different sources of waste (PM Group, 2009). Each source is calculated with special considerations to the origin of the waste. The equation is:

(1) $\boldsymbol{G = G_D + G_M + G_C(kg)}$

Where,
G= quantity of garbage received in a given time period
G_D = quantity of domestic solid waste
G_M = quantity of maintenance solid waste
G_C = quantity of cargo-associated solid waste

Each of the variables is further defined by another equation to give the average waste generated in a time interval. The benefit of this model is that it allows the user to identify the types of waste: domestic, maintenance, and cargo-associated, with their approximate quantities. The variables that make up the total quantity of garbage produced are defined by the following equations.

(A) *Domestic Waste:*

(2) $\boldsymbol{G_D} = G_B + G_P + G_H$

(2.1) $\boldsymbol{G_B} = N_B * T_B * Q_B * P_B(kg),$

Where,
G_B= quantity of domestic waste received from cargo ships
N_B = number of cargo ship calls in a time period
T_B = average duration of voyage for cargo ships
Q_B = average daily domestic garbage generation per person (2.0 kg)
P_B = average number of persons onboard a typical cargo ship (28)

(2.2) $\boldsymbol{G_P} = N_P * T_P * Q_P * P_P(kg)$,

Where,

G_P= quantity of domestic waste received from passenger ships

N_P = number of passenger ship calls in a time period

T_P = average duration of voyage for passenger ships

Q_P = average daily domestic garbage generation per person (3.0 kg)

P_P = average number of persons onboard a typical passenger ship (3500)

(2.3) $\boldsymbol{G_H} = N_H * T_H * Q_H * P_H(kg)$,

Where,

G_H= quantity of domestic waste received from harbor craft

N_H= number of harbor craft engaged in port operations

T_H= average duration of voyage for harbor craft

Q_H = average daily domestic garbage generation per person (1.0 kg)

P_H=the average number of persons onboard a typical harbor craft

(B) Maintenance Waste

(3) $\boldsymbol{G_M} = \boldsymbol{N} * \boldsymbol{T} * \boldsymbol{M}\ (\boldsymbol{kg})$

Where,

G_M = quantity of maintenance waste generated in a time interval

N= number of vessel in port during a given time interval

T= Average duration of ships voyage

M= average quantity of maintenance solid waste generated per day (11 kg/day)

(C) Cargo Associated Waste

(4) $G_C = C_B + C_D + C_C \ (kg)$

C_B (quantity of break bulk cargo waste) = $\frac{quantity\ of\ break\ bulk\ cargo\ recieved}{123}$

C_D (quantity of dry bulk cargo waste) = $\frac{quantity\ of\ dry\ bulk\ cargo\ recieved}{123}$

C_C (quantity of container cargo waste) = $\frac{quantity\ of\ container\ cargo\ recieved}{123}$

We used this model to estimate the waste generated by either port or country, depending on which basis the data was presented. The harbor craft and cargo-associated waste were not included in our data and were disregarded for these calculations. This should not affect our data since harbor craft waste is minimal compared with waste generated by other ship traffic, and cargo-associated waste usually consists of wooden pallets, which can be reused or burned. See Appendix R for an example calculation for ship-generated waste.

3.1.3 Estimate Land-Based Waste Generation

The next step was to estimate the municipal waste generated on each island. This information is important because we needed to compare it with the amount of ship-generated waste received. Since ship-generated waste is ultimately disposed of in the same way as municipal waste, we needed to ensure that the incoming ship waste was not significant enough to overwhelm the land based waste management facilities. This approach estimates the municipal waste needs of each Caribbean state, but does not take into account existing municipal waste facilities and the states' abilities to process that waste. We used this method because we were constrained by the information available on current capacities for waste, thus our calculated data only represents the current amount of waste generated, and assumes they have the ability to manage it.

Estimates on municipal waste generation were found by using each port city's population. The U.S. Virgin Islands' total population was used since their port city's make up most of their country's land area and population. The population was multiplied by a factor for waste generation per day to get total municipal waste. We used the following equation for annual waste generation:

$$W_m = (0.910)P_p(365\ days)$$

Where:

W_m =annual municipal waste generation (kg)

0.910= average daily municipal waste generation in the Caribbean region (kg/person)

P_p = a state's permanent population.

With the mass of municipal waste known, annual cost can then be estimated with the following equation:

$$C_m = (29)1.1 \times 10^{-3} W_m$$

Where:

C_m = annual cost of handling municipal waste, (USD)

1.1×10^{-3} = a conversion factor from kg to tons.

29 = average cost for handling a short ton of municipal waste in the Caribbean region (USD)

The previous equations make a number of assumptions. Values for daily municipal waste generation and the cost of handling municipal waste can actually vary from 0.370 kg/person/day to 2.65 kg/person day and from $15/ton to $105/ton, respectively (Montiero, Mansur, & Segala, 2008). In addition, tourism can have a heavy effect on municipal waste in some locations. Our data does not permit this level of detail in our calculations, so average values were used as an approximation. Constants used in this section are from Montiero, Mansur, & Segala (2008).

3.2 Compare Land and Ship-Generated Waste Amounts

Having identified land and ship-generated waste amounts, the next objective was to compare them. The information put into the Port Call Database was either reported by port or by country. If by port, we compared the port city's waste generation data to the ship waste data, since ship's waste would affect the port city's municipal waste facilities more than the rest of the country. This method resulted in our calculations being on a per port city basis for these samples. Both the U.S. Virgin Islands and Trinidad and Tobago reported their vessel traffic information on a national level. Since the port cities' cumulative populations in each country are closely representative of the entire population, we compared the overall ship waste to overall municipal waste generation. Doing this also resulted in a per port city basis. Since each method gave numbers with the same basis, all of the information could be compared directly.

Total amounts of municipal waste estimates will be used for comparison rather than maximum capacities of waste management facilities for two reasons. The first is that any amount of waste coming into a developing island will put an unnecessary burden on them as well as deplete the minimal landfill area that they do have. The second reason is that the capacities for waste management facilities on SIDS could not be quantified in sufficient detail to be included in the analysis, because those data are not currently available within the scope of this project.

3.3 Propose Regional Collection Plans for Barge-Based Organizations

Our final objective was to provide recommendations on what information should be collected to propose a regional collection plan using a barge-based waste collection system. This plan proposes that a barge or barges would travel through the WCR to collect the ship-generated waste that was offloaded to ports. To do this, we first determined what should be considered as part of a business plan, and modeled our recommendation around it. We then proposed a simplified example to illustrate how our barge-based system would operate.

3.3.1 Plan Considerations and Recommendations

To determine what should be considered when formulating a business plan, we researched similar projects that have been previously completed. We followed a format similar to the ones in these projects, but also included a few different sections that we felt were necessary to go about planning this specific system. Using our background knowledge, we identified different factors that need to be considered when creating this system. To do this, an understanding of waste processing, international laws and limitations, and past management plans was necessary. Information on each of these is described in chapter two of this report.

3.3.2 Example System

Our example system's purpose was to provide an idea of the route that a barge would travel, along with the major expenses that would have to be considered. We first identified a group of islands in close geographical proximity that had all the reported information necessary to formulate a system. The route of the voyage was determined by starting at the home port and progressing through a route of minimal length that includes the other ports. This method was used so that the extra weight from the waste on board would be carried over the shortest distance possible, thus minimizing fuel consumption. The barge would then make its way back in the direction of its home port for waste disposal. Our next step was to determine the costs. To help determine the costs, we defined two categories: One-time charges and recurring costs.

Table 3: Regional Collection Costs

One-Time Costs	USD
Barge	
Crew Training	
Legal Expenses	
Technical Consultants	

Recurring Costs (per month)	USD
Fuel	
Ship Maintenance	
Crew Costs	
Port Fees/ Offloading	

Using the total costs over a specified period of time allowed us to determine the cost the barge organization would have to pay to dispose of the waste. Our example does incorporate all the above costs, but this is a simplified example and does not have every cost included.

4.0 Results and Discussion

In completing our objectives, we obtained data on ship-generated and municipal waste in the Wider Caribbean Region. In this section, we present our results and provide an analysis for each set of data. We analyzed the Port of Call database statistics that we compiled to quantify ship-produced waste. We then compared the results of those calculations to the municipal waste production of each island. The combined information provided enough data to create an example implementation of a regional collection plan.

4.1 Estimated Ship Generated Waste

Estimating ship generated waste is a two-step process. First, we had to establish data on the actual ship traffic by port or country. Second, we had to use that data in calculations to quantify results for waste generation using the equations described in section 3.1.3. This gave us insight into the total burden of waste on the Caribbean, and we describe the results and conclusions below.

4.1.1 Ship Traffic by Country or Port Results

The Port of Call database we created is a compilation of statistics describing the number of certain types of ships that entered a port (See Appendix O). A port of call is any port that is called on by a ship to enter and dock. Our team compiled statistics from port authority websites into a Microsoft Excel spreadsheet labeled the Port of Call Database. A port authority is the management authority in charge of a port. To keep track of the ship traffic in a port, port authorities should take data for each vessel's visit, which then should be compiled in a statistical report and uploaded onto the respective country's public port authority web page. The specific characteristics that we were looking to record in each port were the name, size, classification, cruise ship calls, cargo ship calls, container ship calls, tanker ship calls, total ship calls, waste reception facilities and population of the port city. We then used the database, in combination with published methods and equations to determine approximate waste generation by ships (these calculations are described in section 3.1.3). Below is an example of the Port of Call Database we compiled.

Table 4: Port of Call Database Example- Jamaica

Country	Year	Ports	Size	Classification	Cruise ship calls	Container Ship	Cargo Calls	Oil Tanker Calls	total ship calls	Waste Handled	Population
Jamaica	2009	Port of Black river	Very Small	Pier, Jetty or Wharf						V	
		Port of Kingston	Medium	Seaport	2	1930	236	143	2533		579137
		Port of Lucea	Small	Harbor					0		
		Port of Montego Bay	Small	Harbor	117				336		96474
		Port Ocho Rios	Small	Harbor	211				222	V	8189
		Port Antonio	Small	Pier, Jetty or Wharf	6				10	V	13118
		Port of Esquivel	Very Small	Pier, Jetty or Wharf					81		
		Port Kaiser	Very Small	Pier, Jetty or Wharf					17		
		Port of Rhoades	Very Small	Pier, Jetty or Wharf					87		
		Port Royal	Small	Pier, Jetty or Wharf					0		
		Port of Rio Bueno	Very Small	Pier, Jetty or Wharf					26		
		Port of Rocky Point	Very Small	Pier, Jetty or Wharf					84		
		total			333	1930	236	143	3396		696918

The table above depicts information gathered from Jamaica's Port Authority webpage. This table is typical of how much information is available and how much information was not posted for most countries or territories. The blank boxes in table 5 represent information that was not posted on the port authority page. The numbers represent how many ships of each type visited the port in the year 2009. The classification determines what type of port it is and the size such as; a harbor is a protected port by a peninsula and a pier, jetty, or wharf is a pier that just extends out into the water that is unprotected by land (World Port Source, 2010). The population column is the population of the port city surrounding the respected port.

4.1.2 Database Gaps

In compiling the Port of Call Database, a total of 201 ports were identified in the Wider Caribbean Region. However, of the 201 ports, only 15 ports had substantial enough publicly available data to be used in calculations (see Appendix N). For other ports, data were found on tonnage imported and passenger visits, but those data sets were not applicable to the waste estimation calculations. In order to ensure that we included all of the statistical data, we searched each port authority of the countries and ports looking for other ship call statistics.

For ports for which we could find no or incomplete data, we were not able to determine why the data were not available in the Port of Call Database. However, we suggest several possible reasons the data were not publically available online could be because the local governments or port authorities do not have an established protocol for posting it and/or actively choose not to post it, or do not have the capability to do so. Port authority websites would ideally report the vessel traffic along with other statistics such as cargo information. For some ports, these reports were presented either by port or by country. Often, statistics would be available, but the information provided was not appropriate for our database and calculations. In other situations, no statistical information was available or the countries did not have a port authority website. In such cases, we attempted to contact the port authority directly but we did not receive a reply.

The IMO released a questionnaire in 1999 called the Ship Waste Assessment Form that they suggested be filled out for each vessel entering a port (see Appendix K). The information obtained from this questionnaire would include ship characteristics, cargo information, and waste handling information. Data compiled from the questionnaire would allow outside agencies to determine the capacity of reception facilities and give the respected port authorities a tool to evaluate their needs relating to traffic and waste reception. Because this form is not required to be filled out, this limits the information resources available to the IMO and others in the international shipping community.

This problem could be remedied by the IMO requiring an annual overview of the responses from the questionnaire or similar data compiled at the port or national level. If the questionnaires were filled out by each port, or even by each country, in-depth analysis could be completed in the future to determine the adequacy of port reception facilities.

4.1.3 Estimated Waste Generation

Calculating ship-generated waste per port was important because it helped us to estimate how much waste the port needs to handle over a period of time. We used mathematical models to calculate two types of waste (annex V) which are generated on all vessels. A variation of the REMPEC model was used because our compiled database did not have all of the necessary data for the standard model. All of the values given in the equations are standards supplied by our liaison, Captain David Condino, and are representative of accepted maritime averages and standards.

This model presents the total garbage received over a period of time as the sum of several different sources of waste. Each source is calculated with special considerations to the origin of the waste. Our objective in completing these calculations was to look for countries with high concentrations of ship-generated waste compared to municipal waste. The results from these calculations are included in Appendix N.

When comparing the calculations against each other, it was important to use the same units. For most of the comparisons, the units were in tons per year, a standard unit of measure for Annex V waste, while Annex I waste is measured in m^3 per year. The measurements produced by the calculations are values representative of unprocessed waste. This is pertinent to cruise ships, where waste engineers incinerate all waste and compact all recyclable material for disposal. Incineration reduces the volume of garbage by 90% and reduces the weight by 70%, allowing for a much smaller volume of waste to either be stored or offloaded (Solid Waste, 2008).

4.2 Land-Based Waste Generation

Given the equation used in chapter 3.2 for calculating municipal waste, the linear relationship between the population of each Caribbean state and our estimation was clear. Because the population of the island is only multiplied by a constant, the population is directly related to quantity of municipal waste. Since population data were much easier to locate than data for ship generated waste or calls at specific ports, we were able to generate a complete set of municipal waste estimates, which is available in Appendix R. These estimates are representative of developing nations, where the average waste produced per day per person is 0.91 kg.

The equations used to calculate the municipal waste are a generalization that may not be applicable to the entire WCR. Some islands are more developed than others, which leads to a larger per capita amount of municipal waste being generated. Despite this difference, the calculations give us insight into the general amount of waste produced on the SIDS, allowing us to use this estimate to compare to the amount of ship-generated waste.

In the countries for which we had ship call data for one or a few ports, the population of the entire country does not represent how the ship-generated waste affects the amount of municipal waste. For these cases, the population of the port city was used. Using this number gave us a better idea of how much the offloading of waste burdened the city directly. The population of the country was used was in several cases where the island was small enough that the port cities were representative of a large portion of the islands.

4.3 Comparing Land and Ship Generated Waste Amounts

The issue of ship-generated waste has faced the Caribbean for a long time, but with the WCR's reclassification as a Special Area, the burden will become more severe. To determine the ultimate burden of ship-generated waste in the WCR, comparisons were made between municipal waste and ship-generated waste.

The comparisons of ship-generated waste to municipal waste were completed separately for total ship calls and for only non-cruise ship calls. Cruise ship waste was excluded from one of the calculation is because it is possible that cruise ships retain their waste until returning to their home port and do not offload it onto the islands. Considering that cruise ships now incinerate most of their waste on board, the management of non-cruise ship generated waste presents a more pressing problem to SIDS, and thus, this was our primary focus for further analysis. For most countries with available data, the results of the calculations revealed that the ship-generated waste was small relative to the municipal waste, and therefore ship-generated waste should not present a large burden on land-based disposal systems. While, our data indicates that ship-generated waste seems insignificant, we do not have a complete set of data for any country to make this a true statement. However, in other countries such as Barbados, where tourism is popular, and ship traffic volume is significant even without cruise ships, the percent of ship-generated waste could be as large as 13 percent of the municipal waste. Ship-generated waste presents a large waste management burden on these small islands (see Appendix K).

Figure 3 Percentage of Total Ship Waste & Non-Cruise Ship Waste vs. Municipal Waste

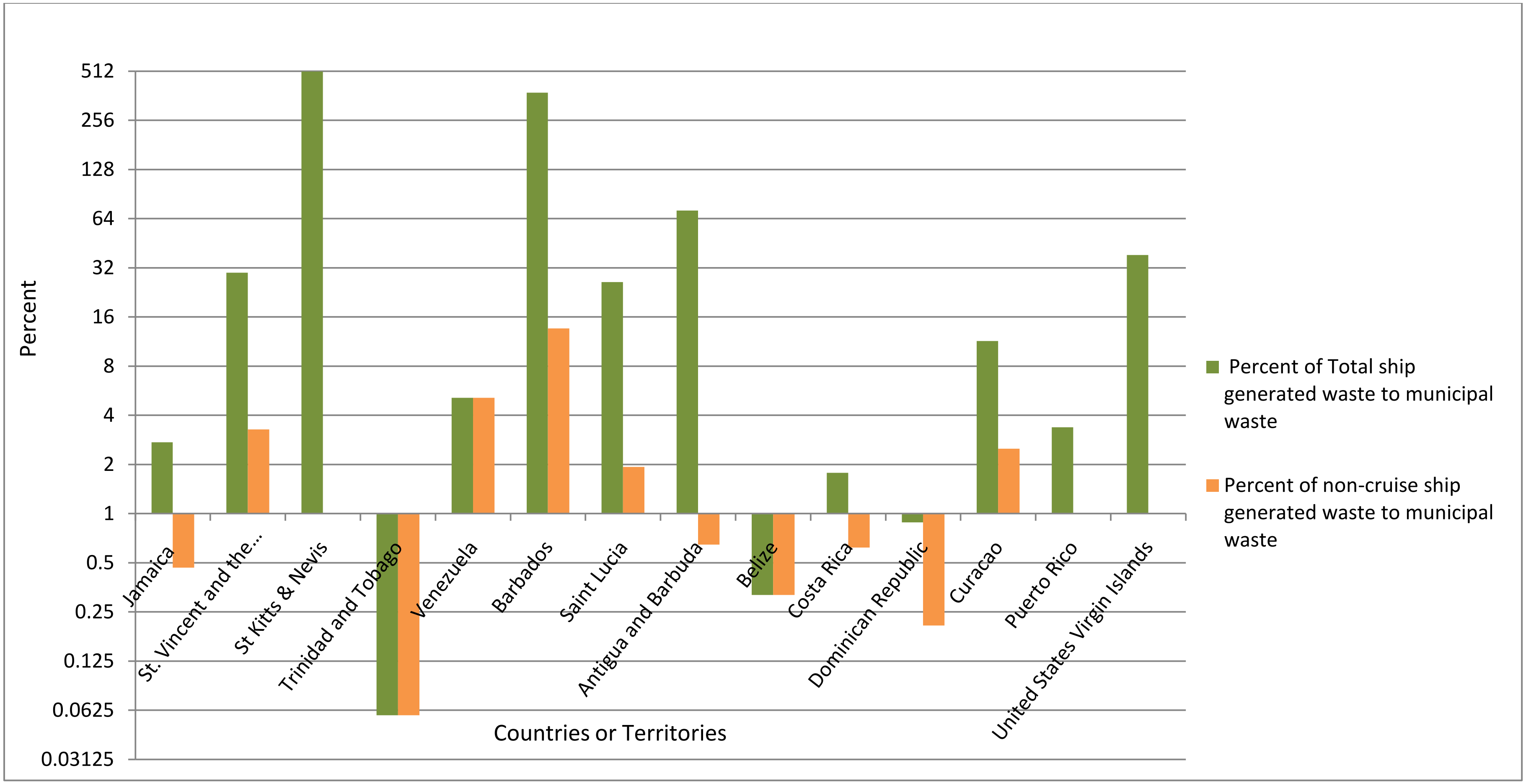


Fig. 2 shows that the ratio of ship-generated to municipal waste varies widely. For three locations, there are no data for the non-cruise ship generated waste, so that the total amount of waste calculated for those islands stems from cruise ship waste. The inverted bars represent percentage values between zero and one to give a more accurate percentage of countries or territories using a smaller scale.

Figure 4 Graph of Ship Generated Waste to Municipal Waste

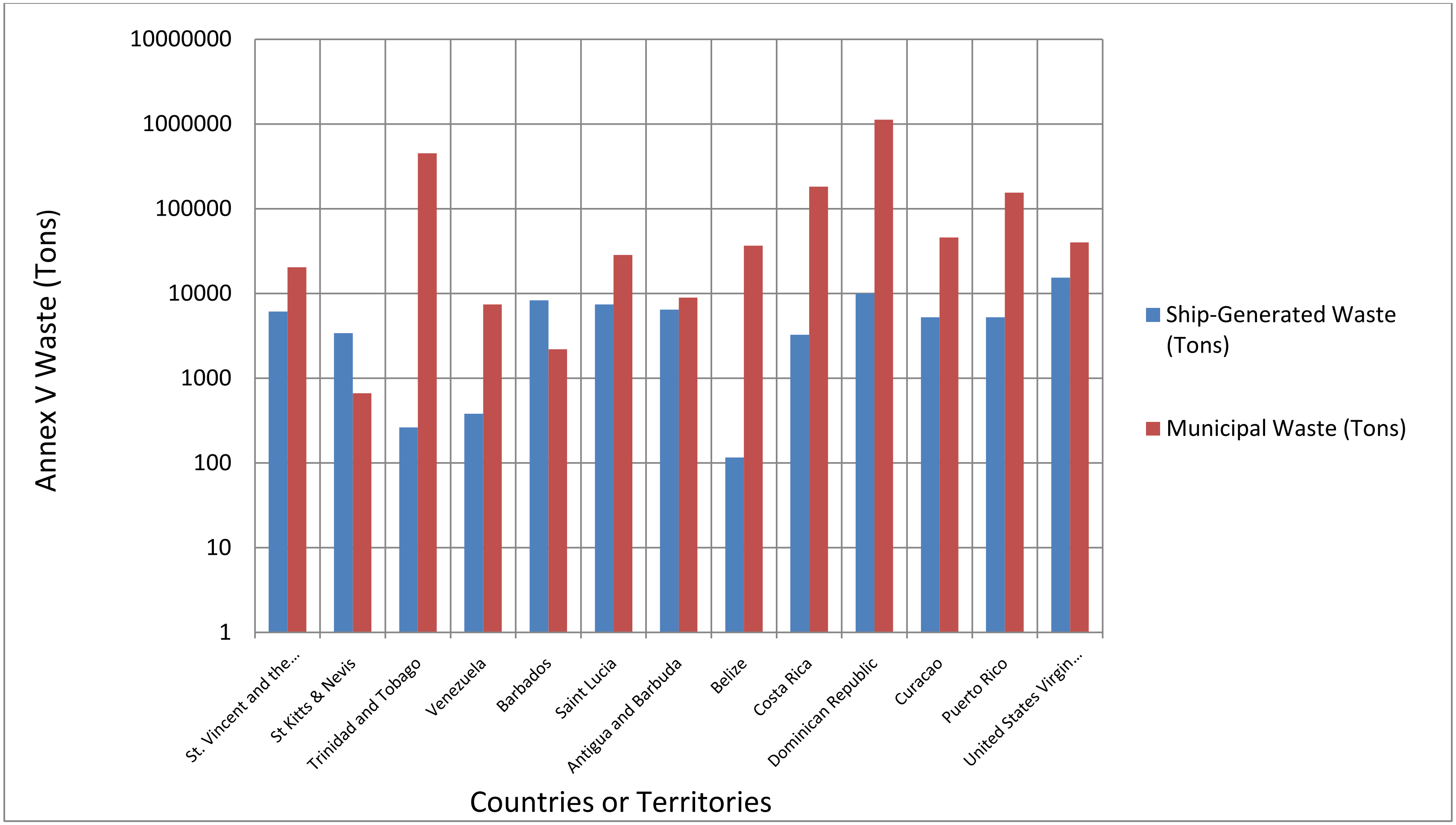


Figure 3 shows a visual representation of the magnitude of waste generated by both municipal and total ship-produced waste using a logarithmic scale so it does not give an accurate visual representation of the ratio between these values.

Because the amount of refuse that is being offloaded into the port cities is going to increase when the new regulations come into effect in May 2011, the port cities may lack the capability and capacity to properly treat the waste to prevent damage to human and environmental health. A regional collection plan could relieve the burden of ship-generated waste completely from the SIDS and allow the waste to be transferred to a location with a larger capacity. If sufficient and accurate data is compiled, then the use of the REMPEC model would yield extremely useful results. The completion of calculations for each individual country would give an idea of how much waste is generated by ships entering the respective ports. If this data analysis was applied the capacities of individual reception facilities and land based waste disposal facilities, it would allow for a regional collection plan to be conceived in sufficient detail to permit its realization. The success of this plan would rely on knowing the amount of additional waste that would be transported from an overburdened port to a port with surplus adequate reception and final disposal facilities.

4.4 Propose Regional Collection Plans for Barge Based organizations

The data that we collected and our estimates for waste generation from the Port Call database and the municipal waste allowed us to theorize a plan to start an organization that collects Annex V garbage from the islands and deposits it at a predetermined location for proper disposal. In order to theorize a regional collection plan, the total yearly waste production values were broken down into waste production per day for each port or country. Then, based on the volume and weight capacity of a barge or other transportation vessel, routes were planned to optimize the waste pick up with regards to time, distance traveled and volume collected. This model is described in chapter 5.0.

5. Model Organizational Plan

In order for a regional waste collection plan to be implemented in the WCR, details related to organizational and economic feasibility need to be analyzed and evaluated. While there are a number of potential solutions available, we chose to pursue regional collection since such a plan would require minimal improvements to land based infrastructure, and is an area of interest to the USCG. In this section, we present a basic plan for an international organizational structure that operates a barge-based regional waste collection system within a set of Caribbean islands. This section is intended to provide a set of considerations and recommendations that will aid in the creation of a plan that allows for the implementation of a regional collection system. An actual system would use more specific details and require more extensive planning, though the information presented in the background and appendices of this report can supplement this research.

5.1 Introduction

Our proposed solution for waste management in the WCR would establish a barge-based regional collection plan for ship generated Annex V. Since regional collection will be a complex project, we will provide practical considerations and recommendations for future data collection and planning. In addition, we will present an example of such a system and provide an estimate of the costs related to running the system. The profitability of such a system will determine how it is organized (e.g., as a private organization, as an organization owned collectively by participating nations or as a cooperative profit or non-profit non-governmental organization).

5.2 Organization Description

This regional collection organization would operate a fleet of barges for the collection of ship generated waste from ports in the Caribbean. This waste would then be delivered to other countries with land-based waste processing and disposal facilities that can properly accept and process these wastes. The system will allow compliance with MARPOL and the Basel Convention after the WCR is reclassified as a Special Area.

5.3 Regional Collection Services

A regional collection system is a waste transportation system among a set of countries. In this system, waste is collected from one subset of countries and is transported to another subset for appropriate disposal. The countries exporting waste under this system should be those which do not have the facilities, methods of transport, resources for expansion, or any other means to ensure its proper disposal. Those importing waste should be those that have the facilities and means to accept and dispose of the imported waste in addition to their own domestic waste.

The organization defined in this section would focus on ship-generated waste, specifically MARPOL Annex V, or garbage. The waste's transportation to final disposal would be as follows:

1. Ship-generated garbage is offloaded into a port's reception storage facility when the ship comes into port;
2. The port reception facility stores the waste on site until it is collected for transport;
3. Organization-operated barges collect waste from the port;
4. Waste collected from barges is offloaded in another port, where it is collected by that port's reception facilities;
5. Waste is transferred from the port reception facility to final disposal, recycling, or treatment on land.

While the entire process has a number of steps, the organization is only required to be involved in the collection of stored waste from port reception facilities and its transfer to another port. Since the material flows through multiple entities, there must be precise coordination on timing, volumes of waste, and advanced notification for temporary and seasonal fluctuations in these factors. Further, the entire system must meet MARPOL's requirements for adequacy in port reception facilities at a regional level. Depending on the overall needs of the system, improvements to port reception facilities in some ports or land-based disposal facilities in waste-importing countries may be necessary.

Depending on which islands are included in the regional system, recycling may be an optional service in addition to garbage disposal. Cost recovery in recycling presents an additional incentive allowing for reduced costs. In addition, if the length of a waste collection cycle permits idle time for organization vessels or other opportunities on ballast voyages, tug boats and barges will also be able to provide local services for that duration.

5.4 Establish Industry Relationships

While the port authorities are typically connected to the government of the nation in which they are located, the port reception facilities are usually managed by private companies under contract with the port authority. These contractors are affiliated or have an agreement with land-based waste disposal companies for final disposal. A regional collection organization needs to establish all of these relationships or assume some of these roles itself. Some of these connections will have to be applied in more than one country.

5.4.1 Legal Considerations of Waste Management in the WCR

Since the waste is being shipped internationally by sea, the regional collection organization will need to maintain compliance with MARPOL and the Basel Convention. The Basel Convention requires an extensive set of agreements and notifications to be in place for the organization to operate. Setting up these agreements will be a major part of coordinating the system between the regional collection organization and participating states. Basel-compliant notifications must be given to the waste importing countries prior to delivery. Since the WCR includes some countries that are not signatories to one or both treaties, the organization will have to make special arrangements for waste collection from non-signatory countries, which are defined in MARPOL and the Basel Convention, respectively. The local laws of the countries in which the organization does business, as well as the countries its fleet sails under, will also have an effect on how it operates.

5.4.2 Analyzing the Regional Market and Competition

Given the necessity of a regular waste collection service and the legal and practical complexity of international waste transport, a regional collection organization will likely be conducted under contractual obligations with waste-exporting ports to ensure regular service. A similar contract with waste-importing ports will ensure that the barges have a reliable location to offload their waste. In a region that already has an existing regional collection system, it will be difficult to enter the market unless the established system provides inadequate services or can be outbid for the next contractual period. One such situation is the case in which the region's quantity of ship generated waste has exceeded the capacity of the waste collection infrastructure.

A regional waste collection organization is also in competition with local methods of disposal in the waste-exporting country. Existing land-based disposal services in these countries can offer local ports an alternative to regional collection, but regional collection should be implemented in areas where local land-based disposal is difficult or cost-ineffective to begin with.

An illegal alternative for ships is to discharge wastes at sea instead of offloading at ports and into the regional collection system. The organization should price its services such that its use provides a cost incentive for offloading waste that is less than the risk of fines for illegal discharge. Mandatory offloading fees can also be implemented to encourage waste offloading in port.

Regions without existing regional collection plans offer more opportunity, provided that there are countries in the region that would benefit from such a system. There are several incentives for stakeholders in ship-generated waste to accept participation in a new regional collection plan. Ship owners and operators can offload waste more conveniently. Port authorities are given a better, more environmentally-friendly option for waste disposal, and local communities do not have to convert more of their limited island area to landfills. Waste-importing countries' port reception facilities receive a fee for the waste brought into their ports. The regional waste accepted by the importing country should be a small percentage of the waste they already process.

The creation of regional adequacy through a barge-based collection system allows countries who could not previously process these quantities of waste to be able to do so. The act of storing the waste rather than processing or disposing of it locally may allow these ports to accept larger amounts of waste than previously possible. The additional wastes received will generate additional business for port management facilities, handlers, and haulers.

5.4.3 Risks

There are also a number of risks that present themselves to an organization operating a regional collection system. Failure of the exporting or importing nations to effectively manage volumes of waste can disrupt the entire system. Furthermore, lack of payments to and from the regional collection organization can result in the loss of business or a barge may be stuck with garbage it is unable to dispose of. In these cases, the system can back up through the preceding steps, increasing the severity of the problem at several stages. This can occur at ports, reception facilities, land-based disposal facilities, or through technical problems in organization vessels themselves.

Additionally, the act of transporting waste over the open ocean presents significant environmental and financial risks. Safety and prevention should be incorporated into equipment and crew training to prevent such spills and accidents. Major incidents could jeopardize the future of the organization or the entire future of regional collection as a means of waste disposal.

5.5 Identifying a Target Market

A regional collection plan must identify a system that contains both waste-exporting and potential waste-importing countries and territories. The system should also be one that presents an economic advantage through the quantity of waste that is available for collection and with the optimization of a collection route to minimize the duration of the voyage and fuel use. In this section, we will present an example system that includes these considerations.

First, we identified a boundary that includes both a waste-importing country (Venezuela) and several waste-exporting countries (St. Lucia, St. Vincent & the Grenadines, Barbados, and Trinidad & Tobago). We chose this set of countries because they each had waste generation data available, and geographically, they are relatively close together. For these reasons, we use this collection of nations as a model to develop a conceptual regional collection plan.

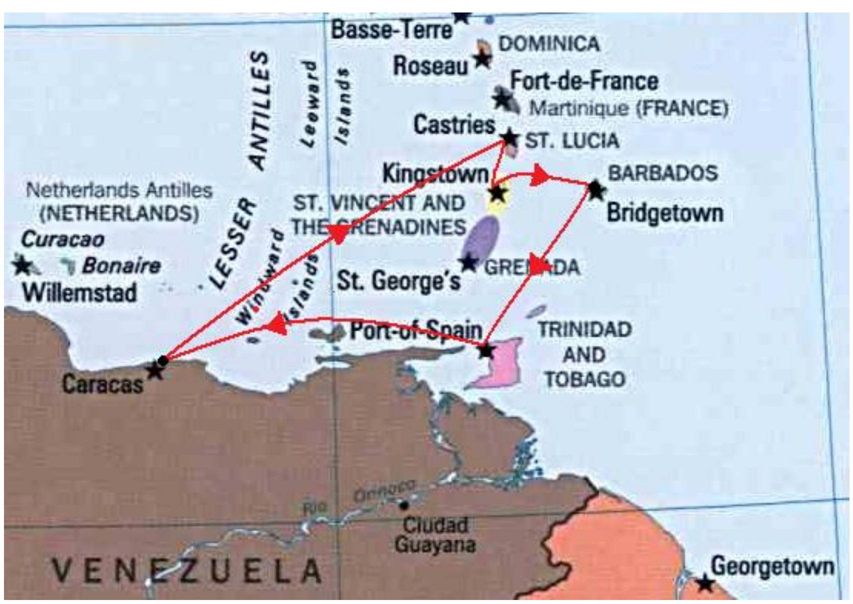
Several factors influence the selection of a transport route. Generally, a shorter route will result in a shorter voyage and less fuel consumption, though ocean currents and typical weather patterns can affect the choice of route. Saving larger collection volumes for last allow the barge to minimize the distance it travels at near-full capacity. Finally, adding more stops may allow for more overall garbage collection, but will lengthen the route and collection cycle.

The collection schedule is also an important matter. For a single ship, this is limited by the duration of the collection cycle, but more complex systems offer more options for optimization. A more frequent schedule may have higher associated ship costs and may result in less garbage carried per load, but it gives less time for garbage to rot while waiting for collection and requires less waste storage capacity in donor ports.

The organization must find a balance among these factors, and its collection plan should include some sort of buffer or adaptability to both the timing of its schedule and its overall capacity to account for volume surges and unexpected inconveniences.

In our example, we decided to minimize the length of the route by distance, though the direction chosen for this route depends on factors outside the scope of our estimation (see figure 4 for route). The resulting schedule was based on the collection cycle of a single barge traveling at 8 knots, and the capacity required by the system, plus a reasonable buffer, would determine the specifications of a barge to be purchased (see section 5.7).

Figure 5: Example waste Collection Route



Modified from *Central America and the Caribbean (2010)*

Next, we quantitatively evaluated expected travel times. Assuming a constant speed of 8 knots, we calculated the days at sea for each leg of the journey. With an estimated 0.2 days in each port for loading or unloading waste, the total duration of an active collection cycle is 6.7 days. We chose a total waste collection cycle length of 7 days to allow for a time buffer of 0.3 days to account for irregularities and fit the waste collection to a standard weekly schedule. We added up the weekly waste to be collected, which will be used for selecting a vessel in section 5.7. The estimates described here can be seen in table 6.

Table 5: Voyage Calculations

Port	Distance (nm)	Days		Projected Waste Collection Tons per 7 Days
		at Sea	in Port	
La Guaira, Venezuela			0	Departure, Empty Ship
to	404	2.1		
Castries, St Lucia			0.2	142.722
to	61	0.3		
Kingstown, St Vincent			0.2	117.064
to	99	0.5		
Bridgetown, Barbados			0.2	159.232
to	203	1.1		
Brighton, Trinidad & Tobago			0.2	5.745
to	329	1.7		
La Guaira, Venezuela			0.2	Return to Home Port
TOTAL	**1 096**	**5.7**	**1**	**424.763**

The system shown here is a fundamental example, though a more accurate assessment of the waste collection and processing needs would require additional data that were not available to us. A more thorough analysis would allow for the refinement to a more efficient system. With the resources available for actual regional collection planning, ship traffic and waste tonnage data can provide accurate assessments of ports' needs and the regional collection plan and give better methods for defining a regional collection system.

5.6 Major Market Trends

With the WCR being reclassified as a MARPOL Special Area, there is new potential for a service providing the benefits similar to that of a regional collection system. In the short term, there is an anticipated surge in the Annex I waste received at ports, as the wastes that were previously discharged at sea are brought to port reception facilities. Accounting for this increase is the primary purpose of the regional collection plan.

With population increasing in most parts of the Caribbean, there will be both a larger load on municipal waste disposal facilities, leaving less capacity available for ship generated waste, and a larger volume of ship traffic to service that population, which will result in more ship generated waste. Both of these factors create more demand for a regional collection plan.

Decreases in waste generation on islands, source reduction for waste generation on ships, and improvements in land-based disposal facilities may mean that less waste is required to be transferred through the regional collection system. While this has implications for the profitability of a regional collection plan, and its sustainability as a private business, the same environmentally-friendly initiatives may produce recycling initiatives and facilities. The potential to expand a collection scheme to include regional collection of recyclable materials can act to offset the loss in the garbage collection market.

Financial projections for individual islands will affect their ability to finance the regional collection service and perhaps have some effect on waste generation as well, but these factors vary from island to island. More detailed data related to waste generation on these islands and the factors that affect it would be necessary to anticipate these changes.

5.7 Determining Management and Organization

Like the World Bank's project for the handling of ship-generated waste for the Organization of Eastern Caribbean States, regional waste collection is an international effort that requires the contributions and coordination of several parties. Commitment and sustainability are critical in all of these areas, as the system needs to be effective for more than just the short term. In this section, we discuss considerations for the organizational structure of the organization and its principal costs.

5.7.1 Planning and Coordination

The planning stage of a regional collection system is critical and complex. Identifying a target market, as shown in our simplified example in section 5.5, is realistically a more in-depth process that takes into account more than just waste material flow. It will be beneficial to hire technical consultants at this stage to ensure that the services the organization will provide will allow for regional adequacy, legal compliance, profitability, and minimize the services' effect on the environment.

For coordination purposes, participating countries should each have national solid waste management entities. Past similar projects including UNEP and World Bank initiatives have also cited the need for an additional entity at the regional level with representatives from the countries' solid waste management entities and other stakeholders. This regional management entity would examine the needs and responsibilities of individual facilities and countries and manage the regional system such that these needs and responsibilities are met. During the planning stage, this regional management entity could take the initiative in data collection for the planning of the system. In a less formal arrangement, the regional collection service itself could assume some of these roles, since the needs and responsibilities of port reception facilities are tied directly to its business. Further, the organization has direct financial interest in the longevity of the system. In a more formal arrangement, the organization may be a single party in a larger and even more international effort, perhaps created or funded by an agency like the World Bank or CDB.

5.7.2 Estimated Costs

It is in this planning stage that the organization would need to address its own costs for the equipment used for its role in the regional collection system. To continue the example presented in Section 5.4, we present some estimations of one-time and recurring costs for the organization in a regional collection system:

Table 6: Estimated Regional Collection Costs

One-Time Costs	USD
Barge	$1,500,000.00
Crew Training	$50,000.00
Legal Expenses	$20,000.00
Technical Consultants	$120,000.00
Total	$1,690,000.00

Recurring Costs (per month)	USD
Fuel	$7,100.00
Ship Maintenance	$1,700.00
Crew Costs	$29,000.00
Port Fees/ Offloading	$39,000.00
Total	$76,800.00

Cost per ton of waste	$46.23

We assume costs for a used, self-propelled, closed-hopper barge with 600 HP and a capacity of approximately 125,000 tons. A ten-person crew is assumed, with a small landside administrative office providing management and support. Estimations for ship and crew operating costs are from Matheny-Katz (2002). Other figures are from personal communication, D. Condino (5 December, 2010), which includes crew training and salaries. The cost per ton of waste is the sum of the recurring costs divided by the quantity of waste handled in one month. While this estimate is subject to a significant margin of error, it does give some insight into the costs of waste disposal in a regional collection system.

Organization personnel including staff, crews, and must be hired and trained. Training should provide for the safe and efficient transportation of waste. In addition to the operators and advisors, the organization would include management to oversee finance and operations. Table 7 includes major expenses, but not all expenses. An actual regional collection organization would likely have an administrative overhead, insurance, and other factors outside of our consideration. A full proposal for a regional collection system must include careful assessments of expenses based on detailed data.

Once the organizational structure is established, the regional collection plan has been defined, and the equipment and personnel are prepared, the organization's primary concerns are maintenance and adaptations to changes in the region. Maintenance includes salaries and expenses relating to owning and operating the organization fleet. The fleet must be upgraded periodically. Service lives, increased environmental friendliness, and advances in maritime technology will justify these changes as time progresses.

5.7.3 Recycling and Cost Recovery

Before waste is ultimately disposed of procedures should be taken to reduce reuse and recycle. There are many types of material that can be reused or recycled that are generated aboard a ship such as paper, metal, glass and plastic. Waste can also be reused as fuel in waste-to-energy incineration. Smart recycling practices are currently implemented on many vessels but ensuring that the port and the barge-based collection system properly segregate and dispose of recyclable materials is important to help environmental efforts. Implementing such practices will allow for cost recovery if the recycled waste or energy created from incineration can be sold. Overall, this would help offset the cost of offloading waste for ship owners, port authorities as well as the regional collection service alike.

5.8 Conclusion

There are many factors that go into creating a barge-based regional collection plan, many of which are mentioned here. The technical aspects and feasibility such as international relations, integration into existing port reception facilities, and identifying the needs of this kind of system are topics that need to be researched in depth before a proposal can be presented to the countries in the WCR. Our project has proposed recommendations for the framework to develop a plan to reduce the burden of ship-generated waste in the WCR.

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Appendix A: United States Coast Guard Description

The United States Coast Guard traces its roots back to the 1790's where it started as the United States Revenue Cutter Service. Its earliest purpose was to enforce tariffs on imported goods. After merging multiple times with other government agencies, the Coast Guard has grown considerably, employing over 40,000 fulltime employees. To mirror its growth in staff, its responsibilities have increased as well. (USCG, 2010)

Our first line of defense in a time of war is the Coast Guard. It is generally known to have three basic duties: maritime safety, security, and stewardship. To clarify these responsibilities, eleven missions have been defined and deal with the following: ports, waterways and coastal security, drug interdiction, aids to navigation, search and rescue, living marine resources, marine safety, defense readiness, migrant interdiction, marine environmental protection, ice operations, and other law enforcement. These missions were put in place by the United States Government. (USCG, 2010)

The Coast Guard officially joined the United States military in 1915, which is when the U.S. Revenue Cutter Service became the Coast Guard. In title 14 of the United States Code it says that "The Coast Guard as established January 28, 1915, shall be a military service and a branch of the armed forces of the United States at all times." In times of war, it will act as a part of the Navy and will answer to the Secretary of the Navy. When our coasts are not under attack, it remains under the authority of the Department of Homeland Security (DHS). It shifted to being part of the DHS in 2003 and now answers to the Secretary of Homeland Security in those peaceful times. (USCG, 2010)

The Coast Guard is split into ten major groups denoted by (CG-) followed by a number. This project team will be working under CG-5 which is known as the Assistant Commandant for Marine Safety, Security, and Stewardship. The group will be working in a branch known as CG-54 or the Director of Prevention Policy. The project given to the team deals with port reception facilities, further defining our position in the organizational structure and finally putting us under CG-544 or the Office of Port and Facility activities, see Figure 1. (USCG, 2010)

Being connected to two separate government entities, the Coast Guard is itself funded by the United States government. The prospective budget for the 2010 fiscal year is 9.73 billion dollars. Of that, the mission that gets the most money is the ports, waterways, and coastal security mission. CG-5 is one of the larger divisions meaning personnel along with money from the budget will be allocated to the problem at hand. As for equipment, boats, aircraft, and cutters are all used by the Coast Guard. A cutter is defined as a water craft that has a permanently assigned crew. With money, personnel, and equipment, the Coast Guard has enough resources to implement a plan to fix the problems waste reception causes. (USCG, 2010)

Other agencies are involved with this issue as well. Different parts of the Department of Homeland Security are addressing this issue along with the Environmental Protection Agency. Both involve themselves on the subject of protecting the marine environment. Other agencies involved are the US Department of Agriculture, the Department of State, Animal and Plant Health Inspection Service, and the National Oceanic and Atmospheric Administration. (USCG, 2010)

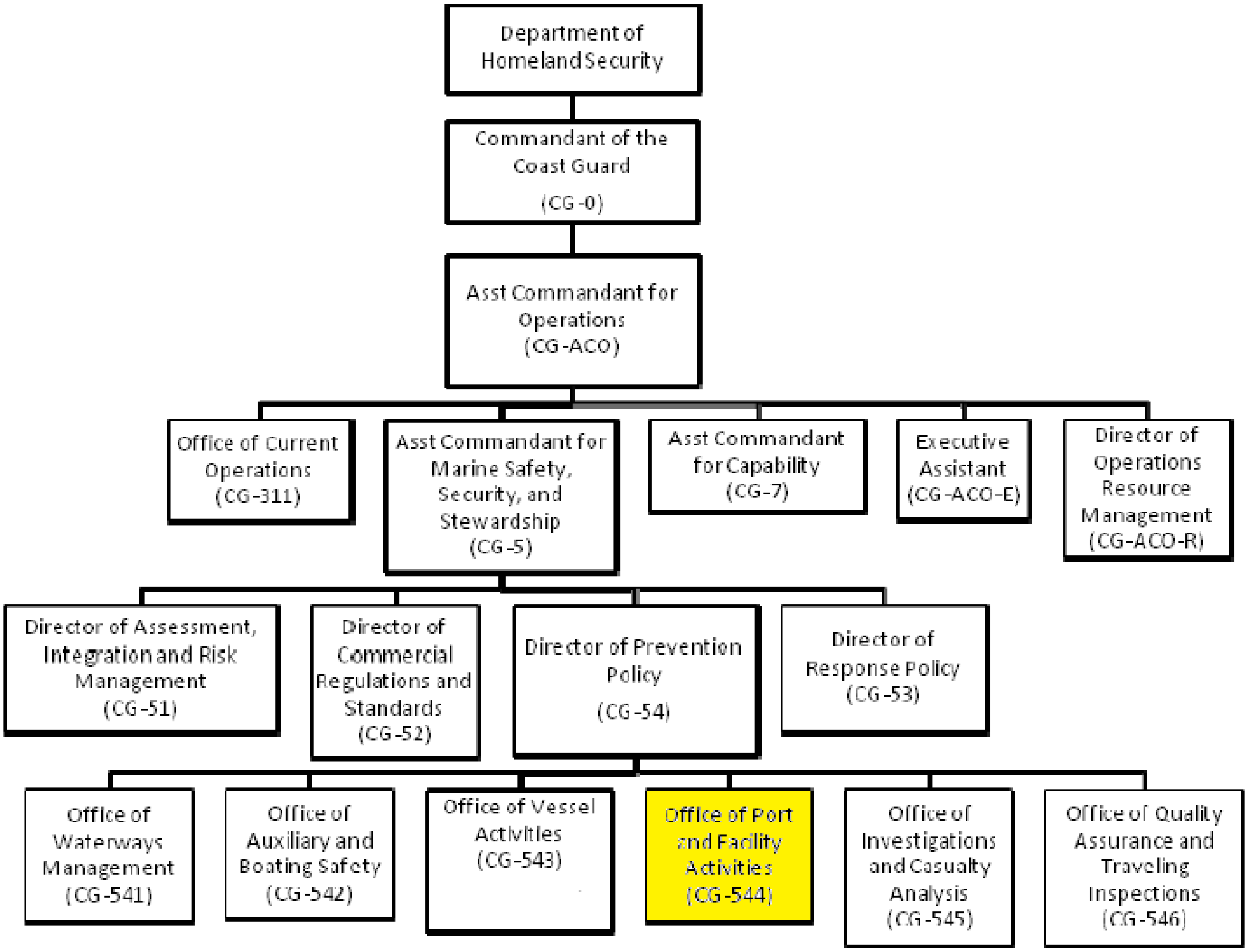

Figure 6-Coast Guard Organizational Flowchart (USCG, 2010)

Appendix B: *Reception Facilities of the Caribbean*

Country	Port City	Service Provider	Waste accepted
Cuba	Mariel	Mariel Port Services Company	Annex V
Barbados	Bridgetown	Barbados Port Inc.	Annex I A
			Annex I B
			Annex V
Saint Lucia	Castries	Saint Lucia Solid Waste Mgt.	Annex V
Aruba	Aruba	Star Enterprises N.V.	Annex I B
			Annex V
		OLA Ship Supplies N.V.	Annex V
		Wevco Supplies and Services N.V.	Annex V
		Associated Transport Company N.V.	Annex V
		Mourik Caribbean N.V.	Annex V
			Annex IV
			Annex I B
Antigua and Barbuda	Antigua	Z-Dummy Selikor N.V.	Annex IV
	St. John's	Department of Marine Services & Merchant Shipping	Annex II
Bahamas	N/A		
Belize	N/A		
Columbia	Barranquilla	Clean Port LTDA, Servi-ship, Delcast E.U, Clean Mar	Annex V
	Cartagena	Supplier Triton LTDA	Annex V
	Covenas	Conectar Limitada	Annex V
	Santa Marta	Desmar LTDA	Annex V
Costa Rica	N/A		
Dominica	Roseau	N/A	
Dominican Republic	N/A		
Grenada	Saint Georges		
Guatemala	Livingston		
	Puerto Barrios	Basic Port	Annex V
		Barco Limpio	Annex V
		DVG Servicios	Annex IB
	Puerto Santo Tomas de Castilla	Barco Limpio	Annex V
		Basic Port	Annex V
		DVG Servicios	Annex IB
Note: Annex 1A: Oily Bilge Water, Annex 1B: Sludge, Annex 1C: Dirty Tank Washing, Annex 1D: Dirty Ballast Water			

Country	Port City	Service Provider	Waste accepted
Guyana	N/A		
Haiti	N/A		
Honduras	Puerto Cortes	Empresa Nacional Portuaria	Annex V
Jamaica	N/A		
Netherlands Antilles	Bullenbaai	Bullenbay Terminal	Annex IA
			Annex IC
			Annex ID
	Emmastad	Emmastad Refinery	Annex ID
			Annex IA
			Annex IC
	Sint Eustatius	N/A	
	Sint-Maarten	Oil MOP	Annex IA
		Clean St Maarten	Annex V
	Willemstad Curacao	Bullenbay Terminal	Annex IA
			Annex IC
			Annex ID
		Selikor	Annex V
Nicaragua	Puerto Sandino	N/A	
St. Kitts & Nevis	Basseterre	N/A	
St. Vincent's & Grenadines	N/A		
Suriname	Moengo	Moengo Dock Operations	Annex V
	Paramaribo	Vensur Port	Annex V
		De Molen Inc.	Annex V
Trinidad & Tobago	N/A		
Venezuela	Puerto La Cruz	N/A	
Note: Annex 1A: Oily Bilge Water, Annex 1B: Sludge, Annex 1C: Dirty Tank Washing, Annex 1D: Dirty Ballast Water			

(IMO, 2000-2010)

Appendix C: *Waste Discharging Regulations*

Garbage Type	All Ships		Offshore platforms and ships within 500 m of them (Regulation 4)
	Outside special areas* (Regulation 3)	In special areas* (Regulation 5)	
Plastics (includes synthetic ropes and fishing nets and plastic garbage bags)	Disposal Prohibited	Disposal Prohibited	Disposal Prohibited
Floating Dunnage, lining and packing materials	25 nautical miles off shore or more	Disposal Prohibited	Disposal Prohibited
Paper, rags, glass, metal, bottles, crockery, and similar refuse	12 nautical miles off shore or more	Disposal Prohibited	Disposal Prohibited
All other garbage (including paper, rags, glass, ect.),comminuted or ground waste	3 nautical miles off shore or more	Disposal Prohibited	Disposal Prohibited
Food Waste not comminuted or ground	12nautical miles off shore or more	12 nautical miles off shore or more	Disposal Prohibited
Food Waste comminuted or ground	3 nautical miles off shore or more	12 nautical miles off shore or more	12 nautical miles off shore or more
Mixed Refuse Types	The more stringent requirements (Regulation 3(2))		
*special areas Mediterranean Sea, Baltic Sea, Black, Sea, Gulf Area, North Sea, Antarctic, Wider Caribbean Region (Regulation 3(1)), Red Sea			
(UNEP, 2005)			

Appendix D*: Dissolving Materials at Sea*

Time taken for objects to dissolve at sea	
Paper bus ticket	2-4 weeks
Cotton cloth	1-5 months
Rope	3-14 months
Woolen cloth	1 year
Painted wood	13 years
Tin can	100 years
Aluminum can	200-500 years
Plastic bottle	450 years

(IMO, 2002)

Appendix E: *List of MARPOL Member States*

Albania	1993
Algeria	1963
Angola	1977
Antigua and Barbuda	1986
Argentina	1953
Australia	1952
Austria	1975
Azerbaijan	1995
Bahamas	1976
Bahrain	1976
Bangladesh	1976
Barbados	1970
Belgium	1951
Belize	1990
Benin	1980
Bolivia (Plurinational State of)	1987
Bosnia and Herzegovina	1993
Brazil	1963
Brunei Darussalam	1984
Bulgaria	1960
Cambodia	1961
Cameroon	1961
Canada	1948
Cape Verde	1976
Chile	1972
China	1973
Colombia	1974
Comoros	2001
Congo	1975
Cook Islands	2008
Costa Rica	1981
Côte d'Ivoire	1960
Croatia	1992
Cuba	1966
Cyprus	1973
Czech Republic	1993
Democratic People's Republic of Korea	1986
Democratic Republic of the Congo*	1973
Denmark	1959
Djibouti	1979
Dominica	1979
Dominican Republic	1953
Ecuador	1956
Egypt	1958
El Salvador	1981
Equatorial Guinea	1972
Eritrea	1993
Estonia	1992
Ethiopia	1975
Fiji	1983
Finland	1959
France	1952
Gabon	1976
Gambia	1979
Georgia	1993
Germany	1959
Ghana	1959
Greece	1958
Grenada	1998
Guatemala	1983
Guinea	1975
Guinea-Bissau	1977
Guyana	1980
Haiti	1953
Honduras	1954
Hungary	1970
Iceland	1960
India	1959
Indonesia	1961
Iran (Islamic Republic of)	1958
Iraq	1973
Ireland	1951
Israel	1952
Italy	1957
Jamaica	1976
Japan	1958
Jordan	1973
Kazakhstan	1994
Kenya	1973
Kiribati	2003
Kuwait	1960
Latvia	1993
Lebanon	1966
Liberia	1959
Libyan Arab Jamahiriya	1970
Lithuania	1995
Luxembourg	1991
Madagascar	1961
Malawi	1989
Malaysia	1971
Maldives	1967
Malta	1966
Marshall Islands	1998
Mauritania	1961
Mauritius	1978
Mexico	1954
Monaco	1989
Mongolia	1996
Montenegro	2006
Morocco	1962
Mozambique	1979
Myanmar	1951
Namibia	1994
Nepal	1979
Netherlands	1949
New Zealand	1960
Nicaragua	1982
Nigeria	1962

Norway	1958
Oman	1974
Pakistan	1958
Panama	1958
Papua New Guinea	1976
Paraguay	1993
Peru	1968
Philippines	1964
Poland	1960
Portugal	1976
Qatar	1977
Republic of Korea	1962
Republic of Moldova	2001
Romania	1965
Russian Federation	1958
Saint Kitts and Nevis	2001
Saint Lucia	1980
Saint Vincent and the Grenadines	1981
Samoa	1996
San Marino	2002
Sao Tome and Principe	1990
Saudi Arabia	1969
Senegal	1960
Serbia	2000
Seychelles	1978
Sierra Leone	1973
Singapore	1966
Slovakia	1993
Slovenia	1993
Solomon Islands	1988
Somalia	1978
South Africa	1995
Spain	1962
Sri Lanka	1972
Sudan	1974
Suriname	1976
Sweden	1959
Switzerland	1955
Syrian Arab Republic	1963
Thailand	1973
The former Yugoslav Republic of Macedonia	1993
Timor-Leste	2005
Togo	1983
Tonga	2000
Trinidad and Tobago	1965
Tunisia	1963
Turkey	1958
Turkmenistan	1993
Tuvalu	2004
Uganda	2009
Ukraine	1994
United Arab Emirates	1980
United Kingdom of Great Britain and Northern Ireland	1949
United Republic of Tanzania	1974
United States of America	1950
Uruguay	1968
Vanuatu	1986
Venezuela (Bolivarian Republic of)	1975
Viet Nam	1984
Yemen	1979
Zimbabwe	2005
Associate Members:	
Hong Kong, China	1967
Macao, China	1990
Faroes	2002

(IMO, 2009)

Appendix F*: List of Global Environmental Facility Partners*

Global Environment Facility Partners
UN Development Programme
UN Environment Programme
World Bank
UN Food and Agriculture Organization
UN Industrial Development Organization
African Development Bank
Asian Development Bank
European Bank for Reconstruction and Development
Inter-American Development Bank
International Fund for Agricultural Development

(Global Environmental Facility (2010))

Appendix G*: Port Reception Facility Implementation Costs*

Port Reception Facilities For Garbage At St. George's Capital Cost Estimate			
Capital Base Costs-Major Ports			
Item	Number	Unit Cost	Total
20' ISO Containers	3	3,000	9,000
MARPOL V Bins	150	400	60,000
Flat Bed Truck	1	40,000	40,000
Barge with Hoist	1	125,000	125,000
Start up and Training	Lump Sum	30,000	30,000
Total			264,000
Description of port equipment implemented at St. George's in US$			

(World Bank, 1995)

Appendix H: *Cost Benefit Analysis of St. Kitts and Nevis*

Year	Recurrent Cost Current	Current Government Contribution	IC&I Contribution		Marine Visitor Contribution		Stayover Visitor Contribution		Net Revenue	Revenue Excess (Shortfall)
			Tipping	Haul	Levy	Haul/ Disposal	Levy	Haul/ Disposal		
1	1,002,000	282,000	0	185,000	0	11,000	0	401,000	737,000	282,000
2	1,767,000	499,000	55,000	199,000	62,000	12,000	78,000	62,000	967,000	800,000
3	1,822,000	514,000	118,000	213,000	134,000	13,000	169,000	75,000	1,236,000	586,000
4	1,879,000	530,000	127,000	227,000	144,000	14,000	182,000	81,000	1,305,000	574,000
5	1,937,000	546,000	136,000	242,000	155,000	15,000	198,000	88,000	1,380,000	557,000
6	1,977,000	563,000	146,000	260,000	168,000	16,000	214,000	95,000	1,462,000	535,000

(World Bank, 1995)

Appendix I*: Actual Costs of the Program Exceeded Estimates*

Countries	Total Appraised Cost (US$m)			Total Actual Cost (US$m)		
	Total Cost	***Govt. Contribution***	***Donors***	***Total Cost***	***Govt. Contribution***	***Donors***
Antigua & Barbuda	5.59	1.59	4.00	6.68	2.10	4.58
Dominica	5.13	1.02	4.11	5.19	0.00	5.19
Grenada	5.24	1.75	3.49	6.12	1.94	4.18
St. Kitts & Nevis	5.30	1.58	3.72	8.41	0.00	8.41
St. Lucia	7.68	1.73	5.95	9.16	0.26	8.90
St. Vincent and the Grenadines	7.57	1.98	5.59	7.78	2.74	5.04

(Chakrapani, D., & Libman, M. (2006).)

Appendix J: *International Associations of the WCR*

	ACS	CARIFORUM	CARICOM	OECS	OSPESCA	CDB	CPEC
Anguilla	X	X	X	X		X	X
Antigua and Barbuda	X	X	X	X		X	X
Aruba	X						
Bahamas	X	X	X			X	
Barbados	X	X	X			X	
Belize	X	X	X			X	
British Virgin Islands	X	X	X	X		X	X
Cayman Islands	X	X	X			X	
Colombia	X						
Costa Rica	X				X		
Cuba	X						
Dominica	X	X	X	X		X	X
Dominican Republic	X	X					
Grenada	X	X	X	X		X	X
Guadeloupe	X						
Guatemala	X				X		
Guyana	X	X	X			X	X
Haiti	X	X	X			X	
Honduras	X				X		
Jamaica	X	X	X			X	X
Mexico	X				X		
Martinique	X						
Montserrat	X	X	X	X		X	X
Nicaragua	X				X		
Puerto Rico	X						
Saint Kitts and Nevis	X	X	X	X		X	X
Saint Lucia	X	X	X	X		X	X
St. Vincent and the Grenadines	X	X	X	X		X	X
Suriname	X	X	X				
Trinidad and Tobago	X	X	X			X	
Turks and Caicos Islands	X	X	X			X	
United States Virgin Islands	X						
Venezuela	X						
Netherlands Antilles	X						

Data from Andrade, 2010, CDB, 2010, and CPEC, 2010.

Appendix K: *Ship Waste Assessment Form MARPOL 73/78*

1. SHIP CHARACTERISTICS

Tonnage : ....
Number of crew/passengers : ....
Last port of call : ....
Time spent in Special Area
during last voyage (days) : ....
Next port of call : ....
Type of propulsion/fuel : ....
Year of construction : ....
Ship type : ❑ Tanker
❑ Container ship
❑ Dry cargo
❑ Passenger/cruise ship
❑ Naval ship
❑ Other, i.e. ....

2. CARGO INFORMATION/OPERATIONS IN PORT

❑ Loading cargo
❑ Unloading cargo
❑ Tank washing
❑ Bunkering
❑ Deballasting
❑ Other, i.e...
Describe cargo/products on board subject to the provisions of:

❑ Annex I :...
....

❑ Annex II :...
....

(IMO 1999)

Appendix K: *Ship Waste Assessment Form MARPOL 73/78 Continued*

3. WASTE HANDLING OPERATIONS AND FACILITIES

ANNEX I – OILY WASTES (bilges, sludge, ballast, slops)

Describe on board facilities for storage and processing of oily wastes (type and capacity of separators, volume of waste storage tanks, etcetera):

....

....

Describe quantities of waste currently on board (in m^3 or tons):

Dirty ballast	:	Bilges	: ....
Slops	:	Sludges	: ....
Tank washings	:	Others	: ....

Describe quantities of waste that have been discharged during last voyage (in m^3 or tons):

....

....

Estimate quantities of waste that will be generated on board while in the port (tank washings, bilges, etc; in m^3 or tons):

....

....

ANNEX II – NOXIOUS LIQUID SUBSTANCES CARRIED IN BULK

Describe on board facilities for storage of chemical wastes (volume of storage tanks in m^3):

....

....

Describe quantities and types of waste currently on board (in m^3 or tons):

....

....

Describe quantities and types of waste that have been discharged during last voyage (in m^3 or tons):

....

....

Estimate qunatities and types of waste that will be generated

Appendix K*: Ship Waste Assessment Form MARPOL 73/78 Continued*

while staying in the port (tank washings, etc.; in m³ or tons):
....
....

ANNEX IV – SEWAGE

Describe on board facilities for treatment and storage of sewage (type, capacity, volume of storage tanks, etc.):
....
....

Describe quantities of sewage currently on board (in m³ or tons):
....
....

Estimate quantity of sewage generated per day (in m³ or tons):
....
....

ANNEX V – GARBAGE

Describe on board facilities for processing of garbage:
....
....

Describe quantities of garbage currently on board (in m³ or tons):

Domestic waste .... Cargo-associatedwaste........
Maintenance waste .... Others ....

Describe garbage segregation practices on board (food waste, glass, metal, paper, etcetera):
....
....

Describe quantities and type of garbage which have been discharged during last voyage (in m³ or tons):
....
....

4. ADDITIONAL REMARKS
....
....
....

Appendix L*: Map of Known Ship Call Countries*

Figure 7: ***Map of the Caribbean Islands*** **(2008)**

Appendix M*: Total Calculations and Percentages of Known Ship Call Countries*

Country	Calculated Total Ship-Generated Waste (Tons/year)	Cruise Ship Waste (Tons/year)	Non-Cruise Ship Generated Waste (Tons/year)	Calculated Oil Waste Generated (M^3/ year)	Municipal waste (Tons/year)	Percent Total ship generated waste to municipal waste	Percent non-cruise ship generated waste to municipal waste
St. Vincent and the Grenadines	6104.06782	5434.063425	670.004395	5769.320256	20413.88546	29.9015483002	3.282101276
St Kitts & Nevis	3402.8001	3402.8001	0	0	666.3546799	510.6589932723	0
Trinidad and Tobago	262.1082009	0	262.1082009	2256.979452	450321.3943	0.0582046965	0.058204697
Venezuela	379.9793445	0	379.9793445	3271.95246	7432.417584	5.1124595763	5.112459576
Barbados	8302.855392	8003.524725	299.330667	2577.497244	2195.309154	378.2089359050	13.63501202
Saint Lucia	7441.954683	6892.406325	549.548358	4732.089068	28437.23516	26.1697546953	1.93249574
Antigua and Barbuda	6429.471189	6371.569575	57.901614	498.583232	8952.218834	71.8198617357	0.64678506
Belize	116.3202075	0	116.3202075	1001.6181	36649.50739	0.3173854596	0.31738546
Costa Rica	3250.252803	2118.06945	1132.183353	9749.08284	182602.4178	1.7799615376	0.620026485
Dominican Republic	9966.377107	7638.939	2327.438107	20041.26527	1125213.103	0.8857324077	0.206844206
Curacao	5224.478717	4079.887875	1144.590842	9855.922104	45766.11813	11.4156037939	2.500956797
Puerto Rico	5225.728725	5225.728725	0	0	154475.2938	3.3828896489	0
United States Virgin Islands	15399.40658	15399.40658	0	0	40210.11138	38.2973487258	0
Total Burden (Tons/year)	78480.79261	70347.6837	8133.108907	70033.13755	2358497.219		

Appendix N: *Calculations of Known Ship Call Countries Part I*

Country	Ports	Size	Classification	Cruise ship calls	Cruise Ship Waste (Kg/year)	Container Ship Calls	Container Ship Waste (Kg/year)	Container Ship Oil Waste (m^3/year)	Cargo Ship Calls	Cargo Ship Waste (Kg/year)	Cargo Ship Oil Waste (m^3/year)
Jamaica	Total			333	5244750	1930	905170	8591.65748	236	110684	1050.586096
St. Vincent and the Grenadines	Total			313	4929750	533	249977	2372.721988	580	272020	2581.94888
St Kitts & Nevis	Total			196	3087000	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Nicaragua	Total			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Trinidad and Tobago	Total			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	507	237783	2256.979452
Venezuela	Port of La Guaira	Medium	Seaport	0	0	612	287028	2724.401232	123	57687	547.551228
Barbados	Total			461	7260750	579	271551	2577.497244	[redacted]	[redacted]	[redacted]
Saint Lucia	Total			397	6252750	323	151487	1437.878428	681	319389	3031.564116
Antigua and Barbuda	Total			367	5780250	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Belize	Total			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	206	96614	917.037016
Costa Rica	Total			122	1921500	1010	473690	4496.15236	1044	489636	4647.507984
Dominican Republic	Total			440	6930000	3845	1803305	17116.54042	[redacted]	[redacted]	[redacted]
Curacao	Port of Willemstad	Small	Seaport	235	3701250	1198	561862	5333.059928	[redacted]	[redacted]	[redacted]
Puerto Rico	Port of San Juan	Medium	Seaport	301	4740750	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
United States Virgin Islands	Total			887	13970250	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Appendix N: *Calculations of Known Ship Call Countries Part II*

Country	Oil Tanker Calls	Oil Tanker ship Waste (Kg/year)	Oil Tanker ship Oil Waste (m^3/year)	Total Ship calls	Calculated Waste Generated (Metric Tons/year)	Calculated Oil Waste Generated (M^3/ year)	Total Waste Generated per day (Kg/day)
Jamaica	143	67067	636.583948	3396	6974.991743	10278.82752	19.10956642
St. Vincent and the Grenadines	183	85827	814.649388	1411	6104.06782	5769.320256	16.72347348
St Kitts & Nevis	[redacted]			196	3402.8001	0	9.32274
Nicaragua				218	0	0	0
Trinidad and Tobago				507	262.1082009	2256.979452	0.71810466
Venezuela				735	379.9793445	3271.95246	1.0410393
Barbados				1040	8302.855392	2577.497244	22.74754902
Saint Lucia	59	27671	262.646524	1460	7441.954683	4732.089068	20.38891694
Antigua and Barbuda	112	52528	498.583232	479	6429.471189	498.583232	17.61498956
Belize	19	8911	84.581084	225	116.3202075	1001.6181	0.3186855
Costa Rica	136	63784	605.422496	2202	3250.252803	9749.08284	8.9048022
Dominican Republic	657	308133	2924.724852	4942	9966.377107	20041.26527	27.30514276
Curacao	1016	476504	4522.862176	2865	5224.478717	9855.922104	14.31364032
Puerto Rico	[redacted]			301	5225.728725	0	14.317065
United States Virgin Islands				3,502	15399.40658	0	42.190155

Appendix O: *Port Call Database*

Country	Year	Ports	Size	Classification	Cruise ship calls	Container Ship	Cargo Calls	Oil Tanker Calls	total ship calls	Waste Handled	Population
Jamaica	2009	Port of Black river	Very Small	Pier, Jetty or Wharf						V	
		Port of Kingston	Medium	Seaport	2	1930	236	143	2533		579137
		Port of Lucea	Small	Harbor					0		
		Port of Montego Bay	Small	Harbor	117				336		96474
		Port Ocho Rios	Small	Harbor	211				222	V	8189
		Port Antonio	Small	Pier, Jetty or Wharf	6				10	V	13118
		Port of Esquivel	Very Small	Pier, Jetty or Wharf					81		
		Port Kaiser	Very Small	Pier, Jetty or Wharf					17		
		Port of Rhoades	Very Small	Pier, Jetty or Wharf					87		
		Port Royal	Small	Pier, Jetty or Wharf					0		
		Port of Rio Bueno	Very Small	Pier, Jetty or Wharf					26		
		Port of Rocky Point	Very Small	Pier, Jetty or Wharf					84		
		total			333	1930	236	143	3396		696918
Nicaragua	2010	El Bluff Port	Very Small	Pier, Jetty or Wharf					77		1500
		El Rama Port	Small	River Port					100		14828
		Puerto Cabezas	Very Small	Pier, Jetty or Wharf					41		39428
		total			N/A	N/A	N/A	N/A	218		55756
St Kitts & Nevis	2008	Port of Basseterre	Small	Seaport						V	
		Port of Charlestown	Small	Pier, Jetty or Wharf	196					V & I	1820
		Total			196	N/A	N/A	N/A	N/A		1820

St Vincents & Grenadines	2008	Port of Arnos Vale	Small	Pier, Jetty or Wharf							
		Port of Canouan	Very Small	Pier, Jetty or Wharf							
		camden Park Bay	Small	Seaport	75	284	337	78	774		
		Port of Kingston	Small	Harbor	66	249	243	79	637	V	13044
		Port Elizabeth	Small	Harbor	172						5316
		Total			313	533	580	183	1411		18360
Suriname		Port of Nieuw Nickerie	Small	River Port							
		Port of Paramaribo	Medium	River Port							
		Total			N/A	N/A	N/A	N/A	N/A		
Trinidad and Tobago	1999	Port of Brighton	Very Small	Pier, Jetty or Wharf							
		Port of Chaguaramas	Small	Harbor						V	
		Port of Cronstadt island	Very Small	Harbor						V	
		Crown Point Harbor	Very Small	Harbor							
		Galeota Point Harbor	Small	Harbor							
		Port of Point Fortin	small	Pier, Jetty or Wharf						I	
		Port of Point Lisas	Small	Pier, Jetty or Wharf						I & V	
		Pointe-a-Pierre harbor	Small	Seaport						I & V	
		Port of Spain	Small	Seaport						I	
		Port of Scarborough	Small	Harbor							
		Port of Trembladora	small	Pier, Jetty or Wharf						V	
		Total			N/A	N/A	507	N/A	N/A		
Venezuela	2010	Port of Alcasa	Small	River Port							
		Port of Amuay bay	Small	Seaport						I	

		Port of Bachaquero	Small	Seaport							
		Bajo Grande Refinery	Small	off-shore terminal						I	
		Port of Caripito	Very Small	River Port						I	
		Port of Carupano	Small	Harbor							
		Port of Cuidad Bolivar	Very Small	Pier, Jetty or Wharf							
		Port of Chistobal Colon	Small	Pier, Jetty or Wharf							
		Port of Cumana	Small	Harbor							
		Port Sucre	Medium	Seaport							
		Port of El Guamach	Small	Pier, Jetty or Wharf						I	
		El Jose	Small	off-shore terminal							
		El Palito Terminal	Very Small	Pier, Jetty or Wharf						I & V	
		Port of El Tablazo	Small	Seaport							
		Port of Guanta	Small	Seaport							
		Port if Guiria	Small	Harbor							
		Bitor S.A Monobouy	Small	off-shore terminal							
		Petrtoterminal	Small	Pier, Jetty or Wharf							
		Petrozuata Monobouy	Small	Pier, Jetty or Wharf							
		Sincor Jose Maine Terminal	Small	Pier, Jetty or Wharf							
		Port of La Guaira	Medium	Seaport	0	612	123		735		20300
		Port of La Salina	Small	Seaport						I	
		Port of Las Piedras	Small	Seaport							
		Port of Matacaibo	Small	Harbor						V	
		Port of Matanzas	Small	River Port							
		Port of Moron	Small	Pier, Jetty or Wharf							

		Port of Pamatacual	Medium	Seaport							
		Port of Pertiga,ete	Small	Pier, Jetty or Wharf							
		Puerto de Puerto La Cruz	Small	Harbor						I & V	
		Port of Puerto Cabello	Medium	Seaport						I & V	
		Port of Puerto de Hierro	Small	Pier, Jetty or Wharf							
		Puerto Miranda	Small	Seaport						I	
		Puerto Ordaz	Small	River Port						V	
		Port of Punta Cardon	Small	Pier, Jetty or Wharf						I	
		Port of Punta de Palmas	Small	Harbor							
		Port of Punta Piedras	Medium	Seaport							
		Port of Punto Fijo	Small	Seaport							
		Port of San Felix	Small	River Port							
		Total			0	612	123	N/A	735		20300
Country	**Year**	**Ports**	**Size**	**Classification**	**Cruise ship calls**	**Cargo Calls**	**Container Calls**	**Oil Tanker Calls**	**total ship calls**		
Aruba		Oranjustad	Medium	Deepwater Seaport							
		Barcedara	Small	Harbor							
		San Nicolas	Medium	Harbor							
		Total			N/A	N/A	N/A	N/A	280		
Barbados	2009	Bridgetown	Small	Harbor	461	579			1040		5996
		Total			461	579	N/A	N/A	1040		5996
Saint Lucia	2008	Castries	Small	Seaport	397	178	322	6	903		61341
		Cul-de-Sac	Small	Seaport					0		
		Vieux-Fort	Small	Harbor		145	359	53	557		16329
		Soufriere	Very Small	Pier Jetty,							

				Wharf							
		Total			397	323	681	59	1460		0
Antigua and Barbuda		Saint John's	Small	Harbor	367			112	479		24451
		Total			367	N/A	N/A	112	479		24451
Bahamas		Clifton Point	Small	Harbor					0		
		Freeport	Medium	Seaport					0		
		South Riding Point	Very Small	Pier Jetty, Wharf							
		Ocea Cay	Very Small	Pier Jetty, Wharf							
		Inagua Islands	Very Small	Pier Jetty, Wharf							
		Marsh Harbor	Small	Harbor					0		
		Nassau	Small	Seaport					0		
		Total			N/A	N/A	N/A	N/A	N/A		
Belize		Belize City	Small	Harbor			206	19	225		100100
		Total			N/A	N/A	206	19	225		100100
Cuba		Havana	Large	Seaport					0		
		Santiago de Cuba	Large	Seaport							
		Cienfuegos	Medium	Seaport							
		Total			N/A	N/A	N/A	N/A	N/A		
Colombia		Barranquilla	Medium	Seaport							
		Cartagena	Large	Seaport					842		
		Cienaga	Small	Pier Jetty, Wharf							
		Covenas	Very Small	Offshore Terminal							
		Mamonal	Seaport	Medium							
		Muelles El Bosque	Small	Port Terminal							
		Pozos Colorados	Very Small	Offshore Terminal							
		Puerto Bolivar	Small	Seaport							

		San Andres Island	Small	Harbor							
		Santa Marta	Small	Harbor							
		Tolu	Small	Pier Jetty, Wharf							
		Turbo	Small	Seaport							
		Total			N/A	N/A	N/A	N/A	N/A		
Costa Rica		Puerto Limon	Medium	Seaport							408738
		Moin	Small	Harbor							90000
		Total			122	1010	1044	136			498738
Dominica		Woodbridge Bay	Small	Pier, Jetty, Wharf							
		Roseau	Small	Seaport							
		Portsmouth	Small	Harbor							
		Total			N/A	N/A	N/A	N/A	N/A		
Dominican Republic	2009	Arroyo Barril	Small	Pier, Jetty, Wharf							
		Barahona	Small	Harbor							80400
		Boca Chica	Small	Seaport							54300
		Cabo Rojo	Very Small	Pier, Jetty, Wharf							46911
		Catalina Island	Small	Pier, Jetty, Wharf							301
		La Romana	Small	Harbor							215600
		Manzanillo	Very Small	Pier, Jetty, Wharf							12100
		Palenque	Very Small	Off-Shore Terminal							31915
		Puerto Viejo de Azua	Very Small	Pier, Jetty, Wharf							62100
		Caucedo	Medium	Seaport							17643
		Rio Haina	Medium	Harbor							163100
		San Pedro de Macoris	Small	Harbor							219600
		Santo Domingo	Medium	Harbor							2169300

		Total			440	3845	N/A	657			3073270
Grenada		Saint George's	Small	Harbor							
		Total			N/A	N/A	N/A	N/A	N/A		
Guatemala		Puerto Barrios	Small	Harbor							
		Santo Tomas de Castilla	Small	Harbor							
		Essequibo River	Small	Pier, Jetty, Wharf							
		Total			N/A	N/A	N/A	N/A	N/A		
Guyana		Georgetown	Medium	Seaport							
		Kaituma	Very Small	River Port							
		New Amsterdam	Small	Rver Port							
		Cap Haitien	Small	Seaport							
		Total			N/A	N/A	N/A	N/A	N/A		
Haiti		Corail	Very Small	Pier, Jetty, Wharf							
		Gonaives	Small	Harbor							
		Jacmel	Small	Harbor							
		Jeremie	Small	Harbor							
		Les Cayes	Very Small	Pier, Jetty, Wharf							
		Miragoane	Very Small	Pier, Jetty, Wharf							
		Petit Goave	Very Small	Pier, Jetty, Wharf							
		Port de Paix	Small	Harbor							
		Port-au-Prince	Small	Seaport							
		Saint Marc	Small	Pier, Jetty, Wharf							
		Puerto Cortes	Small	Seaport							
		Total			N/A	N/A	N/A	N/A	N/A		
Honduras		Tela	Small	Pier, Jetty, Wharf							

		Castilla	Small	Harbor							
		Ceiba	Small	Harbor							
		Coxen Hole	Small	Harbor							
					N/A	N/A	N/A	N/A	N/A		
Country	**Year**	**Ports**	**Size**	**Classification**	**Cruise ship calls**	**Cargo Calls**	**Container Calls**	**Oil Tanker Calls**	**total ship calls**		
Anguilla		Port of the Valley	Small	Pier, Jetty or Wharf							
		Total			N/A	N/A	N/A	N/A	N/A		
Bonaire		Kralendijk	Small	Pier, Jetty, or Wharf							
		Bopec Terminal	Small	Off-Shore Terminal							
		Total			N/A	N/A	N/A	N/A	N/A		
British Virgin Islands		Port Purcell Port of Virgen Gorda	Small	Harbor Pier, Jetty, or Wharf							
		Port of Virgen Gorda	Small	Pier, Jetty, or Wharf							
		Total			N/A	N/A	N/A	N/A	N/A		
Cayman Islands	2008	Port of George Town	Small	Pier, Jetty, or Wharf	570				1055		
		Port of Cayman Brac	Very Small	Pier, Jetty, or Wharf							
		Total			570	N/A	N/A	N/A	1055		
Curacao		Port of Willemstad	Small	Seaport	235	1198		1016	2865	125000	
		Bullen Bay	Small	Pier, Jetty or Wharf							
		Caracas Bay	Small	Harbor							
		Fuik Bay									
		St. Michiel's Bay									
		Spanish Waters									
		Total			235	1198	N/A	1016	2865	125000	

Guadeloupe		Port of Pointe-a-Pitre	Medium	Seaport							
		Port of Basse-Terre	Small	Pier, Jetty, or Wharf							
		Total			N/A	N/A	N/A	N/A	N/A		
Martinique		Port of Fort-de-France	Small	Seaport							
		Port of La Trinite	Small	Harbor							
		Port of Marin	Small	Harbor	,						
		Total			N/A	N/A	N/A	N/A	N/A		
Montserrat		Port of Little Bay	Very Small	Pier, Jetty, or Wharf							
		Port of Plymouth	Very Small	Pier, Jetty, or Wharf							
		Total			N/A	N/A	N/A	N/A	N/A		
Puerto Rico	2009	Port of Aguadilla	Very Small	Pier, Jetty, or Wharf							
		Port of Aguirre	Small	Pier, Jetty, or Wharf							
		Port of Arecibo	Small	Pier, Jetty, or Wharf							
		Port of Arroyo	Very Small	Harbor							
		Roosevelt Roads Naval Station	Medium	Seaport							
		Ensenada Honda Harbor	Small	Harbor							
		Port of Fajardo	Small	Harbor							
		Port of Guanica	Small	Harbor							
		Port of Guayanilla	Small	Seaport							
		Port of Isabela Seguanda	Very Small	Pier, Jetty, or Wharf							
		Jobos Bay	Small	Harbor							
		Port of Las Mareas	Very Small	Harbor							
		Port of Mayaguez	Small	Seaport							
		Playa de Humacao	Very Small	Pier, Jetty, or							

				Wharf							
		Puerto de Naguabo	Very Small	Pier, Jetty, or Wharf							
		Port of Ponce	Small	Harbor							
		Puerto Maunabo	Very Small	Pier, Jetty, or Wharf							
		Punta Guayanes	Very Small	Pier, Jetty, or Wharf							
		Port of San Juan	Medium	Seaport	301						421915
		Puerto Nuevo	Medium	Seaport							
		Port of Tallaboa	Very Small	Pier, Jetty, or Wharf							
		Port of Yabucoa	Small	Seaport							
		Total			301	N/A	N/A	N/A	N/A		421915
Saba		Fort Bay	Very Small	Pier, Jetty, or Wharf							
		Total			N/A	N/A	N/A	N/A	N/A		
Saint Barthelemy		Port of Gustavia	Very Small	Pier, Jetty, or Wharf							
		Total			N/A	N/A	N/A	N/A	N/A		
Saint Martin											
		Total			N/A	N/A	N/A	N/A	N/A		
Sint Eustatius											
		Total			N/A	N/A	N/A	N/A	N/A		
Sint Maarten		Port of Philipsburg	Small	Harbor							
		Total			N/A	N/A	N/A	N/A	N/A		
Turks and Caicos Islands		Cockburn Harbor	Small	Seaport							
		Grand Turk Port	Small	Pier, Jetty, or Wharf							
		Port of Providenciales	Small	Pier, Jetty, or Wharf							
		Total			N/A	N/A	N/A	N/A	N/A		
United States Virgin Islands		Port of Christiansted	Small	Harbor							

		Cruz Bay	Small	Harbor							
		Port of Frederiksted	Small	Pier, Jetty, or Wharf							
		Port Alucroix	Medium	Seaport							
		Charlotte Amalie Harbor	Small	Seaport							
		Total			887	N/A	N/A	N/A	3,502		
		Miami	Medium	Seaport	795		1706				
		Port Everglades	Medium	Seaport	1007	1980	105	683			
Florida	2009	Port of Palm Beach	Medium	Seaport							
		Port of Fort Pierce	Small	Harbor							
		Port Canaveral	Medium	Seaport							
		Tampa	Large	Seaport	181	866					
Alabama		Mobile	Large	Deepwater Seaport					1345		
Mississippi		Gulfport	Small	Seaport					235		
Louisiana		New Orleans	Very Large	River Port							
Texas		Houston	Very Large	Seaport							

Appendix P: *Selection of Distances Between Ports*

	Antigua and Barbuda	Barbados	Belize	Costa Rica	Curacao	Dominican Republic	Jamaica	Puerto Rico	St. Kitts and Nevis	St. Lucia	St. Vincent and the Grenadines	Trinidad and Tobago	US Virgin Islands	Venezuela
Antigua and Barbuda		290	1530	1306	519	469	867	261	58	199	247	402	172	488
Barbados	290		1695	1396	558	677	1045	510	316	112	99	203	404	459
Belize	1530	1695		751	1179	1092	696	1302	1480	1603	1602	1624	1373	1321
Costa Rica	1306	1396	751		1079	1188	943	1380	1500	1546	1528	1528	1398	1222
Curacao	519	558	1179	1079		396	586	486	487	488	463	449	423	148
Dominican Republic	469	677	1092	1188	396		428	230	419	587	593	678	302	500
Jamaica	867	1045	696	943	586	428		635	818	952	955	999	710	730
Puerto Rico	261	510	1302	1380	486	230	635		214	412	449	575	114	538
St. Kitts and Nevis	58	316	1480	1500	487	419	818	214		223	266	412	125	470
St. Lucia	199	112	1603	1546	488	587	952	412	223		61	222	309	404
St. Vincent and the Grenadines	247	99	1602	1528	463	593	955	449	266	61		168	340	366
Trinidad and Tobago	402	203	1624	1528	449	678	999	575	412	222	168		466	329
US Virgin Islands	172	404	1373	1398	423	302	710	114	125	309	340	466		440
Venezuela	488	459	1321	1222	148	500	730	538	470	404	366	329	440	

Distances shown are in nautical miles. Source: World Shipping Register.

Data shown not to be used for navigational purposes.

Appendix Q: *Standard Value Basis or Origin*

- 7 day travel basis
  - Average time taken to cross Atlantic Ocean
- 28 persons on a non-cruise ship vessel
  - Average number of crew
- 3500 persons on a cruise ship vessel
  - Average of passengers and crew aboard Carnival and Caribbean Cruise Vessels
- 42 gallons of fuel/barrel
  - Unit definition
- 200 barrels of fuel/ day
  - Estimated average of fuel consumption for ships traveling in WCR
- 2 kg of waste/day/person on non-cruise ship vessel
  - (NEA, 2009)
- 3 kg of waste/day/person on cruise ship vessel

  (NEA, 2009)

Appendix R: *SIDS Statistics*

Country	Population	GDP (2009)	GDP/Capita (2009)	Oil Production (bbl/day)	HDI	Nation	MARPOL	SIDS	Municipal Waste (kg/yr)	(USD/yr)
Anguilla	14436	175.4 million	12200	-	N/A	British Overseas Territory		yes	4,794,917.40	152,957.87
Antigua and Barbuda	86,532	1.522 billion	17880	0	0.800	Independent	yes	yes	28,741,603.80	916,857.16
Aruba	103,065	2.258 billion	21800	2235	N/A	Netherlands		yes	34,233,039.75	1,092,033.97
Bahamas	307,552	9.126 billion	29700	0	0.826	Independent	yes	yes	102,153,396.80	3,258,693.36
Barbados	284,589	5.051 billion	17700	-	0.871	Independent	yes	yes	94,526,236.35	3,015,386.94
Bonaire	see N.A.	see Netherlands Antilles	see Netherlands Antilles	0	N/A	Netherlands Special Municipality			[redacted]	
British Virgin Islands	24491	853.4 million	38500	0	N/A	British Overseas Territory		yes	8,134,685.65	259,496.47
Cayman Islands	49035	2.25 billion	43800	-	N/A	British Overseas Territory			16,286,975.25	519,554.51
Cuba	11,451,652	110.9 billion	9700	-	0.795	Independent	yes	yes	3,803,666,211.80	121,336,952.16
Curacao	142,180	see Netherlands Antilles	see Netherlands Antilles	0	N/A	Netherlands Constituent			[redacted]	
Dominica	72,660	744.7 million	10200	0	0.779	Independent	yes	yes	24,134,019.00	769,875.21
Dominican Republic	9,650,054	79.65 billion	8300	0	0.727	Independent	yes	yes	3,205,265,436.10	102,247,967.41
Grenada	90,739	1.103 billion	10300	0	0.747	Independent	yes	yes	30,138,958.85	961,432.79
Guadeloupe	as France	Included in French GDP	Included in French GDP	-	N/A	French Overseas Department			[redacted]	
Haiti	9,035,536	11.99 billion	1300	-	0.471	Independent	yes	yes	3,001,153,282.40	95,736,789.71
Jamaica	2,825,928	23.80 billion	8400	-	0.742	Independent	yes	yes	938,631,985.20	29,942,360.33
Martinique	as France	Included in French GDP	Included in French GDP	-	N/A	French Overseas Department			[redacted]	
Montserrat	5097	29 million	3400	-	N/A	British Overseas Territory			1,692,968.55	54,005.70
Puerto Rico	3966213	67.82 billion	17100	1783	N/A	United States Commonwealth		yes	1,317,377,647.95	42,024,346.97
Saba	see N.A.	see Netherlands Antilles	see Netherlands Antilles	0	N/A	Netherlands Special Municipality			[redacted]	
Saint Barthelemy	as France	Included in French GDP	Included in French GDP	-	N/A	French Overseas Collectivity				
Saint Kitts and Nevis	40,131	725.8 million	14700	-	0.814	Independent	yes		13,329,511.65	425,211.42
Saint Lucia	160,267	1.745 billion	10900	0	0.772	Independent	yes		53,232,684.05	1,698,122.62
Saint Martin	as France	Included in French	Included in French	0	N/A	French Overseas			[redacted]	

		GDP	GDP			Collectivity			[redacted]	[redacted]
Saint Vincent and the Grenadines	104,574	1.069 billion	10200	0	0.733	Independent	yes		34,734,254.10	1,108,022.71
Sint Eustatius	see N.A.	see Netherlands Antilles	see Netherlands Antilles	-	N/A	Netherlands Special Municipality			[redacted]	[redacted]
Sint Maarten	see N.A.	see Netherlands Antilles	see Netherlands Antilles	-	N/A	Netherlands Constituent			[redacted]	[redacted]
Trinidad and Tobago	1,229,953	26.19 billion	21300	151600	0.805	Independent	yes	yes	408,528,888.95	13,032,071.56
Turks and Caicos Islands	22942	216 million	11500	-	N/A	British Overseas Territory			7,620,185.30	243,083.91
United States Virgin Islands	109825	1.577 billion	14500	15870	N/A	United States Territory		yes	36,478,373.75	1,163,660.12
Netherlands Antilles (dissolved 10/10/10)	227,049	2.8 billion	16000	-	N/A	Netherlands			75,414,325.35	2,405,716.98
Nicaragua	5,995,928	16.62 billion	2,800	-		Independent	yes	Yes	1,991,547,485.20	63,530,364.78
Venezuela	27,223,228	348.8 billion	13,000	2.472 million		Independent	yes	yes	9,042,195,180.20	288,446,026.25
Belize	314,522	2.575 billion	8,400	3,990		Independent	No	yes	104,468,482.30	3,332,544.59
Costa Rica	4,516,220	48.83 billion	11,000	-		Independent	yes	yes	1,500,062,473.00	47,851,992.89

Appendix S: *Example Calculation for Ship-Generated Waste*

We found that the Port of Kingston in Jamaica had 1,930 container vessel calls, 236 cargo vessel calls, and 333 cruise vessel calls in 2009. Since container and cargo ships are calculated in the same manner, we use the same equation. Using the basis of twenty eight people on board and a seven day voyage, we can use the REMPEC formula to determine waste amount. The first equations we can solve are 2.1 and 2.2, which we can then use to calculate equation 2.

(2.1) $\boldsymbol{G_B} = N_B * T_B * Q_B * P_B(kg)$

Cargo: $\mathbf{G_{B1}} =$

$236 \text{ vessels} * 7\text{days} * 2 \text{ kg of garbage per person per day} * 28 \text{ people per vessel}$

Cargo: $\mathbf{G_{B1}}$ =110,684 kg/year

Container: $\boldsymbol{G_{B2}} =$

$1{,}930 \text{ vessels} * 7\text{days} * 2 \text{ kg of garbage per person per day} * 28 \text{ people per vessel}$

Container: $\boldsymbol{G_{B2}}$=905,170 kg/year

(2.2) $\boldsymbol{G_P} = N_P * T_P * Q_P * P_P(Kg)$,

$= 333 \text{ vessels} * 7\text{days} * 3 \text{ kg of garbage per person per day} * 3{,}500 \text{ people per vessel}$

$\boldsymbol{G_P}$ =5,247,750 kg waste/year

(2) $\boldsymbol{G_D} = G_{B1} + G_P + G_H$

Disregarding G_H and including both container and cargo:

$$\boldsymbol{G_D} = 110{,}684 + 905{,}170 + 5{,}247{,}750$$

$$\boldsymbol{G_D} = 6{,}263{,}603 \text{ kg waste/year}$$

Next, maintenance waste can be calculated and added to the result of Equation 2 to find overall waste. All ships fall into this category and will be calculated by total number of ships.

(3) $\boldsymbol{G_M = N * \; T * M(kg)}$

$$\boldsymbol{G_M} = 2499 \text{ vessels/year} * 7 \text{ days} * 11 \text{ kg waste/vessel /day}$$

$$\boldsymbol{G_M} = 192{,}423 \text{ kg waste/year}$$

Again, after disregarding the cargo associated waste, summing equations 2 and 3 will result in equation 1. This is the final step in calculating the overall waste for the Port of Kingston.

(1) $\boldsymbol{G = G_D + \; G_M + G_C(kg)}$

$$\boldsymbol{G} = 6{,}263{,}603 \text{ kg/year} + \; 192{,}423 \text{ kg/year}$$

$$\boldsymbol{G} = 6{,}456{,}025 \text{ kg/year}$$

This example of the Port of Kingston illustrates the method's we used for every port or country in which we obtained information for in the WCR.

Appendix T: Annex I Generation Data

Country	Calculated Oil Waste Generated (M^3/ year)
St. Vincent and the Grenadines	5769.320256
St Kitts & Nevis	0
Trinidad and Tobago	2256.9
Venezuela	3271.9
Barbados	2577.4
Saint Lucia	4732
Antigua and Barbuda	498.5
Belize	1001.6
Costa Rica	9749
Dominican Republic	20041.2
Curacao	9855.9
Puerto Rico	0
United States Virgin Islands	0
Total	70032.5