REPORT
ON THE POTENTIAL
IMPACTS OF CRUISE SHIPS ON
BERMUDA'S ENVIRONMENT

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The present report was compiled with the cooperation of several individuals, scientists, and government officials, willing to discuss and provide information on their areas of expertise and/or management. For several issues, written documentation was not available, and hence it has been attempted to relate the facts given verbally as accurately as possible. I would like to thank all those individuals I have relentlessly pursued over the past few months, and gratefully acknowledge their efforts in searching valuable information in their paper work. Although certain facts and concerns may not be included in this document, it is hoped that it will provide an informative and useful document to several groups of people.

Samia Sarkis- Ph.D.

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EXECUTIVE SUMMARY

Tourism undoubtedly plays an important role in Bermuda's economy. However, the strong demand experienced in the island from cruise ship operators to increase visits, and accommodate larger ships, pose serious questions on the benefit of the cruise ship industry to Bermuda's economy, and the long term impacts of this industry on Bermuda's delicate infrastructure and land-based tourism.

This report has attempted to gather facts on the present management and controls concerning cruise ship activities. More specifically, the focus was put on certain issues listed by the Marine Environmental Committee and the Environmental Committee of the Bermuda National Trust, concerning the cruise ship industry in Bermuda. The present document has attempted to present an overall view of these concerns, however, it is truly a stepping-stone for further investigation in specific areas.

The pool of data acquired in this report has pointed to the laws and regulations which are used or could be used for control of some cruise ship activities; it also reflects the lack of regulations, enforcement, or scientific knowledge available for some issues which may be of potential concern. On the other hand, this report also identifies some of the changes which are to be put into effect as a result of the pressure of a growing cruise ship industry. Some of these changes are improvements, such as the new proposed sewage treatment plant for the Corporation of St. George's, a direct reaction to the increased use of this plant, namely by cruise ships.

The current situation in Bermuda is one regulated by the present cruise ship policy, restricting the number of passengers to 6,000/day; although the reality is closer to 8,000 passengers/day. With the worldwide movement of the cruise ship industry towards larger ships, and the expiration of the Bermuda policy in the year 2000, the government of Bermuda has been prompted to investigate the accommodation of larger ships. There are at present 5 cruise ship berths in Bermuda, 2 in St. George's Harbour, 2 in Hamilton Harbour, and 1 at Dockyard. The latter berth at Dockyard is at present physically capable of accommodating the new super cruise ships. However, both St. George's and Hamilton Harbour require modifications to the existing berths; these modifications are at present under active consideration by the Bermuda Government, with the assistance of a Consultant Planning & Enginneering Firm, based in Miami, Florida (Bermello-Ajamil & Partners.Inc.)

A list of the main points brought forth in this report is given on page 43. However, in brief, it appears that issues raised pertaining to the advent of larger cruise ships relate in major part to Bermuda's small surface area, and to the logistics involved in life on an island; the location of residential homes and other buildings less than 200 yards from cruise ship berths, the management of waste disposal, the compounded effect of land-based tourism and cruise ship tourism, the accommodation of land-based facilities for both visitors and a high resident population, and lastly the multi-use of the marine environment as an aesthetic, touristic and economic asset raise questions on the preservation of the quality of life for both residents and visitors. This ultimately relies on the carrying capacity of Bermuda itself, one of the most important parameters in considering increased tourism, and one which appears to be an unknown for this island.

Much of Bermuda's infrastructure, in terms of waste disposal, transportation, and land-based facilities, is at present heavily impacted by the cruise ship industry. And although, various governmental groups or individuals are aware of the existing limitations of the system, the further impact imposed by larger ships seems to be uncertain in many areas of potential concern. There

is a lack of sound scientific data for many issues concerning long term impact on Bermuda's environment. Scientific research has been sporadic, often in response to complaints with a delayed time interval, and generally of short experimental periods. This allows for some idea of short term impacts, but leaves very little room for prediction of long term impacts. This points to the requirement of multi-disciplinary studies to assess long term impact of such issues as waste disposal, leaching of contaminants, and the effect of sedimentation on coral reefs, issues which are concerned with the preservation of Bermuda's fragile ecosystem.

The Bermudian marine environment appears to receive little protection by statute. The available legislation is adequate for some issues, namely the Oil Spill Act and the Clean Air Act. However, it appears to be lacking or inadequate for all other issues concerning the input of contaminants into the inshore waters, whether they originate from waste disposal, boat cleaning, leaching from antifouling paints, among others. Enforcement appears to be lacking in many areas, and when performed only occurs in Port. Although, newly built cruise ships are designed to be more environmentally friendly in terms of the type of fuel used, waste management, etc., Bermuda must have the regulations to control these activities, and the ability to enforce them.

The modifications required to accommodate super cruise ships may have some benefit to Bermuda, as for example the alteration of Front Street, Hamilton to a plan increasing its value as a waterfront area. Others, such as the proposed plan for St. George's need to be carefully considered to assess the long term benefits brought to the town itself, as a residential town and as a tourist destination. This leads to the ultimate consideration of the contribution of the cruise ship industry to Bermuda's revenue. The overall contribution is significantly less than that received from land-based tourism, in terms of both passenger expenditure and social contributions. The long term impact of the cruise ship industry on Bermuda's infrastructure and environment- in brief, on Bermuda's carrying capacity- needs to be therefore carefully balanced against the economic benefits this industry will bring to Bermuda's economy. Ideally, Bermuda's land and marine environment needs to be attributed a value which may be incorporated in the development of a Tourism plan for the island.

With Bermuda receiving 2% of the cruise ship market worldwide, and a cruise industry making a lesser contribution to the island's economy than the land-based tourism, is the cruise ship industry beneficial to Bermuda, in terms of economy, in terms of quality of life, in terms of long term effects on other forms of tourism? These are questions which need to be addressed in the very near future to assess the direction to be taken by the Ministry of Tourism. The balance between preserving the quality of life in Bermuda for residents and land-based tourists, and improving the island's economy via a growing cruise ship industry is not an easy task, yet it is one which should be strived for in the 21st century.

I. INTRODUCTION

Bermuda's natural beauty, coupled with its cleanliness, luxurious commodities and friendly people, renders it one of the most attractive vacation destination in this part of the world. Tourism hence plays an undoubtedly important role in the island's economy. Although there is a strength of demand in the cruise ship industry of the island's tourism, it has been acknowledged by several groups of people, namely the Department of Tourism and the Bermuda National Trust, that with a small surface area of 21 square miles, a resident population of 60,000 and a yearly influx of tourists, Bermuda's delicate infrastructure may well be impacted in both the short and long term. In a recent presentation, the Department of Tourism acknowledged that " Bermuda has limited resources to adequately handle large groups of visitors who arrive at the same place, at the same time." Although the main concern of the Department lies in imposing strain on areas of transportation, sightseeing and hospitality services, and mostly in ensuring satisfaction in the vacation experience of our visitors, environmental issues need also be considered. At present, the policy has been to limit the total number of cruise ship visitors to 6,000 per day. However, with new ships under construction being over 800 feet in length and carrying 2000 passengers each, the industry is moving towards larger vessels, and the Department of tourism may take the decision of moving with the industry. This potential increase in the number of cruise ships, frequency of cruise ship holidays, and/or larger cruise ships coming to Bermuda, raises concern on the carrying capacity of the Bermuda islands. In order to meet the demands of the future, a well thought out management procedure is necessary. A comprehensive document on the potential impacts of cruise ships may well prove to be an aid to the Department of Tourism's potential future goals, and towards sustainable economic development.

I.1 Current Situation:

Sources: Tourism report, Bermello-Ajamil & Partners Inc., Department of Marine & Ports

A total of 7.1 million people travel by cruise ships worldwide. Bermuda holds 2% of this entire market. The largest market is the Caribbean (48%) followed by the Mediterranean, and Alaska. However, Bermuda is perceived as being unique, and one of the most profitable routes from the East Coast of the States, as the closest destination servicing the North East Coast. The present cruise ship policy in Bermuda restricts the number of cruise ship passengers to 6,000 passengers/day; the reality is closer to 8,000/day. The present policy is due to expire in the year 2,000, and little is known on the content of the upcoming policy, especially in terms of number of passengers. It is however, a fact that all cruise lines are now building bigger ships, with a total additional 30 ships being built over the next 2-3 years. While cruise lines steam ahead, unloading more and more passengers off bigger and more luxurious ships on to the docksides, fundamental questions must be asked about the benefits of the cruise ship industry to Bermuda and its people, and the long term effects on the land-based tourism. The Caribbean is much asking itself the same questions, and envies Bermuda's control up to date on the cruise ship industry. However, Bermuda is experiencing strong demand from cruise ship operators to increase visits to the island. The government of Bermuda is also aware of

the changes that the cruise ship industry is experiencing at the present time. In light of these changes, the government of Bermuda has hired consultant services to advise on the development of cruise ship facilities on the island.

I.2 Present Cruise Ship Facilities:

Bermuda currently has cruise ship berthing facilities at three locations on the island: Hamilton, St. George's and Dockyard. Five cruise ships serve Bermuda on a regular basis during the cruise ship season, extending from April until November. Approximately 4 other cruise ships visit the island on an occasional basis. The total number of passengers brought to the island by cruise ships is approximately 180,000, for a total of 36 trips. The ships that visit regularly are generally around 600-700 feet in length and carry 1000-1600 passengers. Hamilton and St. George's each have two berths that accommodate ships of this size. Occasionally, a third ship can be accommodated in Hamilton alongside the existing container dock. Dockyard has a single cruise ship berth, although this is a deep-water facility and can accommodate larger ships.

The objectives of the government are:1) To ensure that sound and secure berthing facilities are capable of accommodating two cruise ships up to 900 feet in length are provided in both Hamilton and St. George's. 2) To consider options for cruise ship berthing facilities and other associated development in Hamilton should the existing container port be relocated.

I.3 Required Consultant Services from a Specialised Firm:

The increase in size of ship in terms of berthing does not present a problem at dockyard; this berthing site was not originally considered in the consultant's firm report, however, it has at present become incorporated in the said study.

Hamilton: The configuration of the existing dock, as well as the limited manoeuvring space in the harbor present difficulties in accommodating larger ships. The approach channel to the harbour may need dredging. Matters are further complicated by the operations of the island's only container port on the Hamilton waterfront. On-shore facilities for cruise ship visitors are in need of complete review.

St. George's: The berths are unlikely to be able to accommodate larger ships. The existing berths are, in any case, being severely undermined by the thrusters of vessels currently visiting the town. Access to St. George's harbour for the cruise ships is limited to Town Cut; this will be needed to be widened for larger ships. A study has already been undertaken on the expansion of Town Cut, and is available from Works & Engineering.

1.4 Specifications of new super cruise ships:
Sources: Bermello-Ajamil & Partners Inc., TGG Magazine (No. 2330, Sept 16 1998).

Bermuda is at present receiving many of the older ships. The new ships to be expected in Bermuda are not the biggest ones in the line (100,000-ton vessels), but are considerably larger than the ones presently visiting. The average sizes of the new supercruise ships are as follows:

Length ranging from 810' to 918', with the maximum lengths found in the Royal Caribbean Line, as compared to present ships of 600-700 feet. Tonnage equates approx. 70,000 to 85,000 tons for future ships (current vessels approximate 45,000 tons). The number of berths is referred to as the number of lower berths; these are the stable berths in a cabin, but do not include the fold up berths that are present in the cabin. Hence the lower berths capacity of these supercruise ships is in the range of 1,590 to 2,040; which actually yields a maximum capacity of 1,950 to 2,600 per ship (Current: 1,200-1,500 passengers/ship). This excludes the number of crew, which may be estimated to be 1/3 of the total number of passengers, yielding an additional 800 individuals per ship (Current: 600 crew). Although the beam is expanded in

these supercruise ships to approx. 106', the draft changes little and is in the order of 25 (Current beam 90-105')'. The new ships however, are designed to be more manoeuverable, due to an improved propulsion system; however, the type of propeller used in new super cruise ships , may not be necessarily larger, but is known to cause a greater impact on the docks. This implies a greater impact on turbulence, and on the marine environment. However, the new ships built are designed to be more environmentally friendly, and have to comply to international regulations; for example, these ships are designed to have a better wastewater system, improved engine design- i.e. burning less NOx gases- a lower sulfur content fuel, thus reducing SOx emissions, etc.

Bermello-Ajamil & Partners Inc. hired by government to design new berth facilities in Hamilton and St. George's base all their calculations on a specific Design Vessel:

Beam 106', 850 crew, 900-950' length, 28' draft and 2,000-2,500 passengers.

1.5 Latest Update on Proposed Berthing Facilities:

The latest update was presented March 4, 1999 by Bermello-Ajamil & Partners Inc. consultants, and included the following:

Cruise lines coming to Bermuda in the future: Royal Caribbean Line, Princess, Carnival Celebrity and Norwegian Cruise Lines.

In order to accommodate these supercruise ships in terms of berths, the following options have been presented by the Consultant firm. The proposed plans for Hamilton consider a new pier, including 2.5 to 5.5 acres of landfill for on-shore facilities and adequate berths. Dredging of the Harbour is required to allow the continued use of the container dock, as well as dredging of the approach channel. The amount of landfill required is substantial and dredging material from Hamilton Harbour itself, will most probably not be sufficient.

As for St. George's, a plan to expand town cut is in the hands of Works & Engineering. Requirements are for expansion of Town Cut by 15m, encroaching on Higg's Island. Dredging of the Town Cut to deepen the channel from 29' to 30.5' is proposed.

The present docks need to be rebuilt, but include minimal landfill at Ordnance Island. It is proposed that dredging material from St. George's will be utilised for the Hamilton landfill requirements.

Waterfront infrastructure is included in the Consultant firm's report for both sites, attempting to create an efficient and agreeable waterfront. This includes the relocation of bus terminals in both sites, and the linkage of ferry and bus systems in Hamilton. but does not include the carrying capacity of either areas. A first cost estimate was given for Hamilton's revamping, averaging 9.9 to 15.2 million; this however, is a standard cost, and not taking into account Bermuda's prices. There are no cost estimates available for St. George's at this time.

This firm is to be studying the infrastructure required for accommodating the increased flow of passengers at any one time from the cruise ship to various transportation modes, such as buses, taxis and ferries. However, the study does not consider the increased number of people on the whole island, and the issues pertaining to this increase in density; in brief, little consideration is taken on the overall carrying capacity of Hamilton, St. George's and dockyard specifically, and of Bermuda in general.

II. OJECTIVES OF THE PRESENT REPORT:

There is at present a lack of current complete and thorough documentation integrating existing scientific data, current management, and overall impact assessment concerning cruise ship activities in Bermuda. It is therefore proposed that proper documentation be compiled by the National Trust to:

a) integrate the scientific data available relating to cruise ship impact on the marine environment
b) compile the current situation in terms of cruise ship waste management while in port
c) outline the laws and regulations in Bermuda enabling the management of cruise ship activities
d) outline the issues where data is lacking in terms of regulations, scientific knowledge, etc.

In brief, it is attempted to provide as many facts as possible on the current situation relating to cruise ship activities in Bermuda. This is performed by integrating information from several local governmental, private and scientific sources. Unless otherwise noted, most of the information has been gathered through conversations and interviews with managers, officials and individuals well versed in specific issues, as documentation was not available for many of the questions posed; scientific data has been obtained through publications and referred as such. Although this document may not be able to address all issues pertaining to the potential impact of cruise ships, it is hoped that it will yield a clearer understanding of the areas which need to be addressed in order to preserve Bermuda's beauty, charm and quality of life.

III. SOLID AND LIQUID WASTE DISPOSAL: Sewage, recyclable, non-recyclable.

Four different types of wastes generated by cruise ships are considered in this report:

a) Wet Wastes- kitchen wastes
b) Recyclable
c) sewage
d) dry goods & papers

III.1 SEWAGE

According to the Public Health Act, it is the Minister of Health who has the final say on all issues related to sewage.

The following outlines the existing sewage treatment facilities in dockyard, Hamilton and St. George's, as well as the future improvements to each plant, when applicable, and the results of environmental assessment when applicable.

III.1.a Dockyard- WEDCO Plant

Sources: WEDCO Engineer; Government Hydrogeologist

There are three principal sources utilising the WEDCO sewage treatment plant:

1) Dockyard- excluding the Maritime Museum
2) West Gate Prison
3) Cruise ship (s)- not all cruise ships berthed at Dockyard tie into the sewage plant.

The plant is managed by an American Firm (DAWS, Hollywood, Florida). This company also manages the Southampton Princess Hotel Plant.

It is a secondary treatment plant. To a certain extent, this plant provides primary and secondary treatment. Primary treatment normally entails filtration; whereas the WEDCO plant grinds solids rather than filters. Wastes are then transferred to secondary aeration tanks, where aerobic digestion takes place. This attempts to separate grease from other wastes. There are two aeration tanks, each with a capacity of approx. 80,000 U.S. gallons/day. Following this process, the wastes are divided into two parts: 1) Liquid and 2) Sludge.

The liquid part of the effluent goes down 2 boreholes, located in Sally Port, on the NW side of dockyard. Each borehole is 6" in diameter and 60' below seawater level. There are no freshwater lenses in the vicinity which may be potentially contaminated. The closest lens is the Somerset lens.

The sludge is physically removed and transported to Tynes Bay septage tank. This sludge is placed in settlement tanks where it is dewatered. The resulting liquid part goes into the sewer and is disposed of via the corporation of Hamilton Sewage Plant to Hungry Bay. The remainder is transferred to a drying pit, where following 3-6 months of drying, it is taken to the Pembroke landfill; at this time it is mixed with vegetation and made into compost.

The WEDCO treatment plant is relatively efficient with respect to waste treatment, according to government hydrogeologist; although there have been problems in the past in the operation of

the plant. Levels of COD (chemical oxygen demand), BOD (biological oxygen demand) and TSS (total suspended solids) are monitored by the plant engineer. These analyses indicate a marked decrease in all three parameters before and after the primary and secondary treatments, reflecting the efficiency of the plant when operating adequately; results of these analyses further indicate that effluent of the WEDCO plant meets environmental criteria set by the Environmental Authority as explained in section III.1.d below. The volume of sewage treated at the WEDCO plant varies seasonally, and the maximal flow ranges from 160,000-200,000 U.S. gallons/day. Table 1 outlines the average flow of sewage originating from each of the three main sources on a daily basis. It is noted that cruise ships currently account for approximately 55% of the total sewage treated during the cruise ship season.

Table 1. Volume of sewage (U.S. gallons of sewage/day) disposed of into the WEDCO treatment plant. (WEDCO Engineer, *pers.comm*.)

Source	***U.S. gallons of sewage/day***
Dockyard	40,000
West Gate	40,000
Cruise ships (in season)	100,000-110,000

Deep-sealed borehole:

As its name indicates, it is a hole drilled into the bedrock. A casing is made around the hole, usually consisting of plastic or steel. The casing is sealed with cement or another type of grout; this prevents leaching throughout the length of the borehole. The hole is drilled to at least 40' below sea level and up to 150' below sea level. The effluent directed to the borehole comes out below the seawater level and below any potential freshwater lens. Its main purpose is to increase the length of path to the sea, thus decreasing the chances of direct contamination to the lens. It furthermore, allows for dilution and dispersal. Although a deep-sea borehole is not a treatment per say, it performs an adequate function in terms of dilution and dispersal. At Dockyard, the effluent tends to flow to the northwest according to current patterns (Government hydrogeologist, *pers. comm.)*.

The closest freshwater lens to the Dockyard deep-sealed boreholes at WEDCO is the

Somerset lens. This lens is located on the main island, and is not affected by dockyard. However, it lies at a low level, with little distance between the lens and the bottom of the surrounding cesspits. Any contamination to this lens is therefore due to this proximity, and low-lying character, rather than to any other source. The lens may be treated or abandoned in the very near future.

Fees for sewage disposal:

Fees for sewage disposal by cruise ship equate approximately $2.00/registered berth/day. This fee is minimal, and does not cover the cost for sewage treatment (WEDCO Engineer, *pers.comm*.).

Current Issues involving cruise ship sewage disposal at WEDCO:

Sources: WEDCO Engineer, Ministry of Environment

The type of sewage entering the plant is crucial to the operation of the plant, according to WEDCO Engineer. BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) may be analysed to determine the sewage type. In order to maintain the adequate operation of the treatment facilities, there is an agreement between the WEDCO sewage facilities and the cruise ships utilising the plant concerning the type of sewage discharged into the plant. Problems have apparently arisen during the 1998 season, where cruise ship sewage exceeding concentrations acceptable by the WEDCO Engineer (in terms of BOD and COD) was disposed of at the plant. Investigations followed to indicate that the source of this sewage were kitchen wastes from the 5 existing galleys of the said cruise ship. Action was taken to oblige the cruise ship to hold its sewage while berthed at Dockyard. As cruise ships may not hold sewage for a longer period than approximately 4 days, it is probable that this sewage was disposed of somewhere else.

At present, the WEDCO plant is adequate in terms of treating the current volume of sewage (including that of cruise ships during the summer months). However, the problem lies in the type of effluent disposed of to the plant. According to Ministry of Environment officials, agreements between plant engineers and cruise ships relating to sewage disposal are independently drawn for each sewage treatment facilities (Dockyard, Hamilton and St. George's); and, a breach in this agreement entitles plant engineers to put restrictions on cruise ships for the disposal of sewage through their plant. However, there seems to be little support from present regulations allowing for conviction of offenses (WEDCO Engineer, *pers.comm*.).

Future Plans:

Improvements to the sewage treatment plant at WEDCO have recently been made. These allow for the treatment of a larger volume of sewage, and of holding a larger concentration of sewage. These modifications could possibly increase the capacity of the plant.

The need for a further expansion of the plant is uncertain due to the lack of information on the future requirements imposed by super cruise ships. Volume of sewage and type of sewage discharged from new cruise ships are unknown, and are two important factors in the future plans of the WEDCO sewage treatment plant. There is some concern by the WEDCO Engineer as to the sewage management procedure for potential super cruise ships. The present WEDCO engineer intends to prepare a document on the WEDCO sewage treatment facilities, which is to be distributed to various concerned bodies.

III.1.b Hamilton Corporation Sewage Plant:

Sources: City Engineers (Hamilton Corporation), Bermuda Water Consultants, Dr. R. Smith (BBSR).

The Hamilton corporation sewage treatment plant is by far the largest one on the island, in terms of sewage volume on a daily basis. The plant incorporates effluent from the Corporation of Hamilton, Prospect area, Tynes Bay, new projects as for example the National Stadium and Cedarbridge, and King Edward Hospital. The latter has its own pumping station, and ties up to the corporation sewage line at Berry Hill Road, for disposal to Hungry Bay. Although this junction is the responsibility of Works & Engineering, practically, it is maintained by the

Corporation of Hamilton (City Engineers, *pers.comm*.). Approximately 60% of the total sewage comes from outside of the boundaries of Hamilton corporation.

The Hamilton Plant is termed a communition sewage plant. All effluent, aside from King Edward Hospital, flows by gravity to the Court Street holding tank; it is thereafter pumped via the pumping station, located at the junction of Court street and Front street. Pumping rate depends on the flow of wastewater into the holding tank, such that at periods of low flow rate (for example at night time), sewage is pumped for 10 minutes every 40-50 minutes; whereas during times of higher flow rate, sewage is pumped for a period of 10 minutes every 20 minutes. At the pumping station, sewage is passed through macerating pumps, where blades chop all sewage to approx. ¼". Following maceration, the resulting sewage is pumped out to Hungry Bay, South shore; at Berry Hill Road, wastewater from the King Edward Hospital merges with the main sewage line from the pumping station. The main pipe is 18" in diameter, extending 700m from the shore in Hungry Bay; the last 75 m of this pipe consists of 5-7 riser jets, approx. 3-4" in diameter, connected at a right angle to the main pipe. These riser jets force the effluent to flow upwards, thus allowing the dispersal of the effluent as small plumes 1- 1 1/2m above the sea bottom. The maximum depth of the water column is approx. 30'. Once sewage is flushed, a grey odorous pollutant is noticeable at times; however, dispersal is rapid. The sewage is flushed with saltwater.

There are several limitations to the existing system. The pumping station itself is very old, built circa 1910; such that the structure is in bad condition. The pumps themselves are due for renewal. The blades required for grinding need constant adjusting, without which, solids are improperly macerated, and large articles such as plastics end up at the other end of the plant, in Hungry Bay. Furthermore, there lies an existing problem in the build up of oil and grease in the pumping station itself, and in the disposal lines. The current solution is to physically remove this build-up from the pumping station itself every 6-8 weeks. BWC (Bermuda Water Consultants) was hired to perform a pilot study on the effect of the introduction of grease-eating microbes; these microbes liquefy and digest the grease. This method proved successful in terms of grease build up control. It is however, not applied at present, and physical removal of the grease at the pumping station remains the existing solution.

Utilisation of Plant by Cruise Ships:

The cruise ships berthing at Hamilton tie into the Corporation of Hamilton Sewage Treatment plant. Sewage from the cruise ships is flushed with freshwater, and transported along Front Street to the holding tank on Court Street. It is thereafter disposed of via the treatment plant to Hungry Bay with the rest of the Hamilton Sewage. Cruise ships are charged $190-$200 per day for utilising the facilities of the Sewage treatment plant; this cost almost covers the expenses incurred for pumping cruise ship wastewater (City Engineers, *pers.comm*.).

Details on the contribution of individual sources (m^3/day and gallons/day) is given in Table 2 below.

Table 2. The wastewater sources utilising the sewage treatment plant of Hamilton Corporation (taken from Associated Engineering Report # 952WO5\REPORT0996.1\TEXT; Corporation Engineer, *pers.comm*.).

Source	***Average Annual flow (m^3/day)***	***Av. Annual flow gallons/day***	***Percentage of total (%)***
Residential within	290	63,510	14.4

corporation			
Cruise ships	280	61,320	14.0
Government			
Development			
- Tynes Bay Septage facility	85	18,615	4.3
- Residential/Institutional	145	31,755	7.3
Commercial			
- Within Corporation	650	142.350	32.5
- Outside Corporation	550	120,450	27.5
Total	2,000	438,000	100

The maximum total volume of sewage pumped on a daily basis by the corporation of Hamilton is in the order of 1 million imperial gallons/day (City Engineers, *pers.comm.*); the mean value is, however, closer to 500,000 imperial gallons/day, as seen in Table 2. The maximal flow rate noted has only been recorded once in the past 8 years. 35% comes from commercial, institutional, residential development outside of the Corporation boundaries. On an annual basis, the cruise ships account for 14% of the total wastewater flow. In 1994, there were 21 cruise ship days contributing on average 461 m^3 (101,000 imperial gallons) per cruise ship day.

On a final note, according to one engineer at the Hamilton Corporation, the actual volume of wastewater from cruise ship has dropped dramatically in the past 15 years; as the treatments used on board the ship are more efficient at the present time. This statement however is not based on any facts, as the flow rate from cruise ships is not metered, and is not planned to be in the future. It may furthermore reflect a decline in the number of cruise ships berthing in Hamilton during this time.

The potential increase in wastewater production from larger cruise ship has been included in the total estimated increase in sewage for the next 50 years for the Hamilton Corporation Treatment Plant; although incorporation of cruise ship wastewater in the future estimation is tricky, according to one of the engineers at the Hamilton Corporation, as there is no knowledge of wastewater production for supercruise ships, or any information on the type of treatment to be utilised in the new boats. Furthermore, engineers are uncertain as to the future of cruise ship trips in Bermuda. Future estimates are based on the maximal value of 1 million imperial gallons/day.

Future Plans:

All in all, considering the estimated increased flow over the next 50 years, and the unacceptable technology of the present system, with respect to that utilised in other developed countries, the corporation of Hamilton engaged Associated Engineering International Ltd. to carry out a feasibility study to develop a concept for upgrading the Front Street pumping station. A key factor in the future management of wastewater is the location of the treatment plant. With the current level of treatment, it has been possible to locate the works within the densely developed urban area of the Corporation. With increasing levels of treatment, the area of land required would increase dramatically bringing into question the practicality of continuing to provide treatment within the Corporation boundaries given the competing land uses. The intent of this study is to address this issue and determine the feasibility of long term wastewater treatment within the Corporation boundaries. The study thus does not consider or investigate specific sites outside of the Corporation.

The future plans of the existing sewage treatment plant consider the upgrading of the plant to a preliminary treatment, rather than the current communition treatment. A preliminary treatment includes the introduction of filtration by a fine screening system. This will allow for the filtration of sewage coming into the pumping station, thus removing solids. This fine screening system will assist in controlling the grease problem at the pumping station. Bigger pumps, as well as a different system of pumping will be put in effect; where this will allow for the elimination of retention time in the holding tank. The liquid part of the resulting effluent will be disposed of at sea in Hungry Bay. There is a chance of increasing the diameter of the main pipe. The possibility of extending the main pipe beyond the outer reefs, and disposing of sewage is being considered; the decisive factors are the result of scientific studies assessing the impact on adjacent reefs and benthic communities, and the cost of this extension. It is, furthermore, proposed that the solid part of the effluent will be burned using the Tynes Bay incinerator. The latter has not been accepted yet.

Scientific Report:

The Corporation of Hamilton is awaiting the results of scientific studies conducted to assess the potential impact of sewage disposal in the areas adjacent to the outfall. This study was performed by Dr. R. Smith, at the Bermuda Biological Station for Research Inc. (BBSR), and was commenced in 1996, 4 years after the installation of the Hungry Bay outfall as it currently exists. This 2-year study included the following:

1) The analyses of trace metals in the sediments adjacent to the outfall

2) The assessment of benthic communities in the area adjacent to the outfall

3) The assessment of coral reef " health" in terms of species number, diversity and growth rate on the reefs adjacent to the outfall.

The final report is in the making at present (Feb 99), and is to be submitted to Associated Engineers International Ltd. upon completion. However, upon discussion with Dr. Smith, it appears that the limitations of this study are several:

- The time span of the experimental period is short; effectively there is only one year of data obtained for assessing the impact of the sewage disposal, if any.
- There has been no work on microbial communities in sediments surrounding the outfall. This is one of the major impacts of accumulated sludge around sewage outfalls. These microbial communities consist of various organisms, among which are enteric amoebas, a threat to human health.
- The assessment of coral reef " health" in terms of numbers and diversity may not prove to be a sufficiently sensitive indicator of such an impact. Corals are slow growing animals, and several years of a low level impact may be required before recording a change. Dr. Smith will recommend the continuation of studies considering more sensitive stress indicators, such as physiological measurements of surrounding marine fauna (for example, fish), allowing for the assessment of low level stressors.

BBSR study:

The Bermuda Biological Station for Research has analysed sediment samples during practical courses offered (Hazardous Assessment of Marine Contaminants course, 1996). The following trace metals, Manganese (Mn), Lead (Pb), Nickel (Ni), Copper (Cu), and Vanadium (V) were determined in the sediments surrounding the Corporation of Hamilton Sewage Outfall. Results are given below.

Table 3 . Concentrations of dissolved (diss.) trace metals (nmol.l^{-1}) and of sediment associated (sed.) trace metals(microgram.g^{-1}) in Hungry Bay; where, HB1 is closest to outfall, and HB3 furthest (taken from HAMC course, BBSR, 1996).

Site	*Mn diss.*	*Mn sed.*	*Pb diss.*	*Pb sec.*	*Ni diss.*	*Ni sed.*	*Cu diss.*	*Cu sed.*	*V diss.*	*V sed.*
HB1	7.05	12.8	0.93	5.01	5.87	22.7	12.5	3.51	0.59	5.50
HB2	88.4	11.3	1.00	46.2	6.22	21.9	12.5	3.14	1.85	4.66
HB3	356	13.3	1.27	30.8	13.0	21.1	16.4	2.82	2.47	0.36

The following is an excerpt of the discussion following these results:
Hungry Bay sewage outfall demonstrated no trends in trace metals data and typical levels found do not suggest significant anthropogenic contamination in either the dissolved or particulate phase. However, it is important to bear in mind that the sewage pipe does not constantly discharge waste. It is not known whether any material was actually being expelled during sampling, and hence caution advised when interpreting the dissolved concentrations in particular, as any sediment loading are likely to be relatively static and not subject to dilution. It is therefore noted that these results may not be typical of dissolved concentrations present during sewage discharge and hence levels analysed may just be a function of pipe emission events. It is very difficult based on ambient concentrations alone to infer or predict whether the observed distributions are exhibiting any effect on marine biota and hence the trophic network of interactions. So, to answer questions like: Are the levels of trace metals found in Bermuda's Inshore waters hazardous to marine life, or Is there any evidence of toxicity? Requires not only the knowledge of concentration gradients, time dependence and hydrographic regimes in the area under consideration, but vigorous ecotoxicological studies, and hence the need for a multidisciplinary approach to marine environmental concerns.

Dr. Smith's data on other sites adjacent to the Hungry Bay sewage outfall determining the concentrations of sediment associated trace metals is not available at this point in time.

In summary, scientific work has been sporadic, and over short experimental periods, not providing a complete account of long term impacts resulting from sewage disposal.

III.1.b. St. George's Corporation Sewage Plant:

Sources: Foreman at St. George's Corporation, Chairman of Sewage Committee for St. George's Corporation, Government hydrogeologist, Department of Health.

Sewage Treatment plant in St. George's incorporates sewage from within the town of St. George's boundaries. The sewage plant in St. George's is also referred to as a communition plant, similarly to that of the Hamilton Corporation. Sewage is collected in a holding tank near Ordnance island on the waterfront. There are two pumping stations, one in the Market Wharf Area, and the other at Penno's wharf for the collection of sewage from the cruise ship docked at that site. New pumps are on order at present to replace the existing ones. Sewage passes through a grinding stage (blades), and is thereafter pumped over the hill to Tobacco Bay. The pipe extends 1122 ft from Tobacco Bay at a depth of approx. 25'. There are several patch reefs in the vicinity of the outfall. There are at present frequent problems of overflow into St. George's Harbour, and the Public Health Department issued a no bathing sign in the area behind the Visitor's bureau in St. George's'.

The total volume of sewage pumped is in the range of 50,000 to 120,000 imperial gallons/day , as determined by the government hydrogeologist (*pers.comm*.). Estimates show a large variation, however, maximal values are recorded during the cruise ship season, thus estimating a

total of 70,000 imperial gallons of wastewater/day from the cruise ship. This equates 58.3% of the total flow of sewage through the Corporation of St. George's sewage treatment plant.

Future Plans:

The possible advent of the supercruise ships has provided a boost to the Corporation of St. George's Sewage Committee. There exists future plans of establishing a tertiary sewage treatment plant, such that resulting water could be utilised for irrigation or toilet flushing. In the near future, however, (1999/2000), the first phase of installing a small experimental plant is in progress according the chairman of the Sewage Committee in St. George's. Should this prove adequate, a full tertiary treatment plant will be installed. This plant will be large enough to incorporate the sewage from the limits of the town, the hotel on the hill, and the new supercruise ships.

III.1.d Environmental Criteria

Source: Government hydrogeologist

Environmental criteria are set by the Water Authority, now the Environmental Authority. These criteria are set on a case by case basis. This is due to the small size of the Bermuda islands, and to the differences in location of the concerned treatment plants; for example, some hotels are located on the shore of semi-enclosed bodies of water, whereas others are located on the open shores of the ocean. Criteria are therefore different among these.

The maximum standard is currently set for the Marriott Hotel and Southside (see Table 4). Both of these have a tertiary treatment. This treatment allows for water to be recycled and subsequently utilised for toilet flushing. The Marriott hotel was asked in the future to measure nitrates and chlorine residuals. The minimum standard is set for the WEDCO treatment plant. There are no criteria set for either Hamilton or St. George's, at this point in time.

Table 4. Criteria for sewage treatment plant, set by Water Authority, for BOD ($mg.l^{-1}$) and TSS ($mg.l^{-1}$). (Government Hydrogeologist, *pers.comm*.)

Site	*BOD*	*TSS*
Marriott/Southside	10	10
WEDCO	25	35
Hamilton/St. George's	none	none

Although, there has been a lot of studies on engineering for installation of secondary treatment for Hamilton and St. George's, there is no current deadline to implement these according to the government hydrogeologist. Furthermore, the establishment of secondary treatment alone is arguable, as this type of processing does not remove nutrients; hence balancing the cost of establishing a secondary treatment plant, with the fact of not eliminating the nutrient load issue, is a decision to be made by the Hamilton Corporation in the future.

There has been concern as to the potential increase in nutrients at dockyard, however, no funds have been made available to pursue this issue.

Regulatory Measures Currently Taken: *Source: Department of Health, scientific literature*

At present, there exists a water sampling monitoring program to assess the safety of bathing waters. Samples are taken weekly from the surface water during the summer months. Although the main goal is to assess safety bathing on the beaches, some sites are analysed following complaints; as for example, the Penno's wharf site in St. George's. The overflow of the St. George's sewage line is located behind the Visitor's Bureau in St. George's, flowing into the harbour waters. A bad smell emanates from the water when this occurs. Public Health officials have placed a sign, indicating no swimming in this area. Targeted sites are the following:

A. East End: Market Wharf, Tobacco Bay, Penno's Wharf (Zenith), Godet and Young Dock
B. Central ; #1 Dock, #6 Dock, Ferry Terminal, Flag pole, Red Hole, Crow Lane, Norwegian Cruise Line, Zenith (City).
C. West End: Sonesta Beach (Front Bay), Sinky Bay, Cross Bay, Waterlot Inn, Horizon, King's Poing, Riddles Bay, Southampton princess.

The number of samples taken at each site ranged from 1 to 5. Results taken in proximity of cruise ships were based on 1 and 2 samples in 1997. Bacteriological standards for coastal and bathing waters are as follows:

Faecal coliforms < 100 per 100 ml sample
Faecal streptococci <35 per 100ml sample

Of the 74 samples taken, 29.7% failed one or both of the criteria. These were in proximity of Market Wharf, Penno's Wharf, Godet & Young Dock, #1 Dock, #6 Dock, Flag Pole, Crow lane, Sonesta Beach, Sinky Bay, and Waterlot Inn. According to the report by Public Health officials, cruise ships all had acceptable samples except for the Zenith when berthed in Penno's wharf, St. George's.

According to the bacteriological monitoring conducted by Public Health Department , there did not seem to be any evidence of contamination of surface waters and to inshore beaches as a result of sewage outfalls, until recently. This is the only type of monitoring program at present conducted in Bermuda, which is related to potential contamination of surface waters by sewage disposal. The use of *Escheria coli* (*E. coli*) levels in the water column as a classification for suitable recreation (or fishing) waters is common practice; this measure for water quality criteria rests upon the assumption that fecal coliforms closely mimic the behaviour of sewage derived pathogenic bacteria and viruses in the marine environment. Unfortunately, this assumption is not always true. There are other more accurate indicators of fecal pollution, such as chemical indicators. A short student study performed at BBSR in 1993 analysed fecal sterol (coprostanol) levels in sediments off Hungry Bay outfall, among other sites. This study indicated that levels of coprostanol were significantly higher at the Hungry Bay outfall than at other sites (North Rock, Harrington Sound, Hamilton and St. George's Harbours). This indicated the need to pursue investigations in order to assess the long term impact of sewage disposal in Bermuda waters (Mumford, 1993).

III.1.e.Potential impacts of long-term sewage disposal:

There have been no scientific studies conducted to assess the potential impact of the St. Georges' corporation sewage outfall in Tobacco Bay; nor have there been any complete studies performed to assess the potential impact of the WEDCO sewage release from boreholes. The limitations of the work performed for the Corporation of Hamilton has already been discussed in section III.1.b.

There are several factors to consider in assessing the potential impact of sewage:

1. The accumulation of sludge in areas adjacent to the outfall. At present, sludge resulting from the WEDCO treatment plant is transported to Tynes Bay septage tank and disposed of as compost and via the Corporation of Hamilton Sewage plant. The presence/absence of sludge in areas surrounding both the Hungry Bay outfall, and the Tobacco Bay outfall has not been assessed. There exists at present conflicting observations among SCUBA divers who have been in the vicinity of the outfall. The potential long term accumulation of sludge in certain areas has been shown in other areas around the world to potentially lead to:

A. The introduction of microbial pathogens into marine ecosystems. These microbial pathogens include pathogenic protozoans and human enteroviruses, in addition to well-known fecal bacteria. The presence of cyst-forming amoebas has been found to be associated with sewage effluents along the Atlantic and Pacific Coasts of the U.S. as well as at waste disposal sites in the open ocean. A study has been performed by Munson in Bermuda in 1995, in view of assessing potential sewage contamination and nutrient enrichment of inshore waters, by determining the presence of these cyst-forming amoebas (genus: *Acanthamoeba*) in sediments of inshore waters. Findings indicate the presence of potentially pathogenic species of *Acanthamoeba* at 10 of the 15 sites sampled; among these sites are Tobacco Bay and Hungry Bay, sites of sewage disposal (Munson, 1997) . Unfortunately, there was no sampling performed at dockyard. It was concluded that the study supports the concept that certain cyst-forming species of *Acanthamoeba* may be useful indicator organisms of sewage and other nutrient impacts in aquatic ecosystems. Additionally, these organisms may prove useful indicators of habitat recovery as better management practices are developed for the disposal of sewage wastes.

It is furthermore worth noting that the current weekly monitoring by the Public Health Department does not include sediments; hence the levels of fecal bacteria in sediments is not known.

B. The accumulation of heavy metals in sewage disposal areas has been recorded for sites used for a period of <8 years (Sawyer, 1987). The studies performed in Bermuda have been conducted on the Hungry Bay outfall only, excluding that of Tobacco Bay. Moreover, studies conducted have been of a short experimental period - one year of data accumulation-(Smith et al., 1999), or a fixed time sample (HAMC, 1996). None of the studies performed could potentially assess the long term effect of sewage disposal at the same site, whether at Hungry Bay, or Tobacco Bay, with respect to heavy metal accumulation in the surrounding sediments.

C. The accumulation of organic pollutants. Highly contaminated sediments have been shown to be the principal cause of relatively high and persistent concentrations of polychlorinated biphenyls (PCB) residues in tissues of seafood fishes and invertebrates, 5-7 years after a dominant wastewater input (Young et al., 1988). PCB concentrations in fish exceeded in this case the FDA action guideline for PCB. There has been no

determination of organics in the sediments surrounding the Bermuda sewage outfalls.

D. Another consequence of heavy sewage disposal is the input of nutrients into the marine system. Communition, preliminary, primary and secondary treatments do not reduce the nutrient load in the disposed sewage. There has been some interest expressed by certain goverment officials in assessing the nutrient input from the WEDCO site. There has been no studies relating to this issue. Once again, the Hungry Bay outfall benefits from a high dilution rates; it is probable that nutrient change or enrichment may not be of concern at this site. However, sites for WEDCO and Corporation of St, George's may be worth considering. Increased nutrient loads may result in alterations in the biological system of the water column; namely, in the changes of composition of phytoplankton species and in the amount of primary production. Bermuda's inshore waters have relatively low productivity compared to coastal waters of the U.S., atttaining maximal values of 2 micrograms Chlorophyll $a.l^{-1}$ in some of the most enclosed bodies of water (Harrington Sound and Hamilton Harbour). Low nutrient levels are the direct cause of this low productivity. It is probably for this reason that Bermuda has not been subject to many harmful algal blooms, causing an effect on fish and shellfish species,and ultimately on the consumer. There has been however, a monitoring program performed over the past two years by BBSR scientist S. Sarkis, considering the changes in phytoplankton composition on a monthly basis. This program put into light the existence of several species of potentially harmful algae in Bermuda's waters. Furthermore, a bloom of a potentially toxic algae was identified in September 1997, coinciding with a first record of a mass mortality of fish in Harrington Sound. Since 1996, there have been 2 incidences of a bloom of potentially harmful algae in some of Bermuda's inshore waters. The dynamics of bloom formation are not well known, and the processes underlying toxin production by these algae are also not well understood. However, it does appear that increased nutrients, and increased particulate organic matter play a role in the proliferation of potentially harmful algae, and in the stimulation of toxin production by these algae.

The above four potential issues in the long term disposal of sewage/sludge in the same site are important issues to human health. There are, however, a few points to keep in mind for Bermuda itself:

- The volume of sewage disposed of in Bermuda is considerably less than sites where several of these studies have been performed (1million gallons/day for Hungry Bay, as compared to 360 million gallons/day for LA County Sanitation Districts).
- The distribution, fate and effects of wastes in the ocean are governed by the physical, chemical and biological processes of a specific body of water. The Hungry Bay outfall is located in a highly dynamic environment, which will inevitably be of positive benefit to the fate of disposed sewage in this area. The dilution factor at this particular site is extremely high (1000:1). Tobacco Bay has not been very well studied, and is not as much of a high energy environment as the Hungry Bay site. Nutrient enrichment at dockyard has been voiced as a concern; however, the disposal of sludge does not occur at this site, and should be a minimal issue at this time.
- In the long term, contaminants of biological concern, such as trace metals, organic pollutants will increase the potential for alterations of benthic populations through organic enrichment and toxicant impacts. The potential of harmful algal proliferation and its consequences on human health is present in Bermuda waters. The cause of most concern in Bermuda is the lack of control on fish quality for fish taken from local waters sold to the consumer from the local waters.

IV. NON-RECYCLABLE, RECYCLABLE AND COMPOST.

Sources: Ministry of Works & Engineering, Private contractors: Hunt's Sanitation and, David Atcheson

When in port, ships unload their wastes into containers specifically provided for this use.

Zenith and Horizon have 3 containers:

1. Green- for the collection of dry goods and paper- to be burnt at Tynes Bay Incinerator Plant
2. Yellow - for the collection of wet wastes, such as kitchen wastes. According to the Shipping Agent, cruise ships are provided with biodegradable bags by Works & Engineering for the wet wastes. These wastes are transported to Marsh Folly.
3. Blue- for the collection of recyclable material. These are transported to the recycling plant. Recyclable materials of cruise ships consist of compacted glass and compacted aluminum and steel.

The type of trash collected from private contractors is as follows: Food waste and compost, recyclable material, and dry wastes. Two private contractors service cruise ships in Bermuda: Hunt's sanitation, and David Atcheson.

Hunts' Sanitation services Song of America and Norwegian Crown. Collections occur in Hamilton for both cruise ships, and additionally from St. George's for Song of America. A collection occurs every two weeks for recyclables, where the blue container is emptied into an intermediate truck. The compacted glass is taken to Marsh Folly, and the compacted tin is taken to the recycling plant. It is difficult to assess the specific volume of recyclable material collected, as these trucks do not pass over a weight table prior to unloading at Marsh Folly and the Recycling Plant. The only indication may be obtained by the capacity of the intermediate truck itself.

As for dry wastes, approximately 3 ½ - 4 tons of wastes/ship is transported to Tynes Bay Incinerator Plant on a weekly basis. This amounts to approximately 200 tons of dry wastes transported by Hunt's Sanitation on a seasonal basis for the two ship mentioned above (Song of America and Norwegian Crown).

David Atcheson Waste services Celebrity cruises (Horizon /Zenith). The wet wastes are composted and sent to Marsh Folly; the recyclables are sent to the recycling plant; and the dry wastes are sent to Tynes Bay. Once again, only estimated volume may be calculated for the dry wastes sent to Tynes Bay in terms of no. of bins/ship.

For the Zenith, David Atcheson Waste made 184 collections for 26 cruise ship voyages.

For the Horizon, 304 collections were made for 27 cruise ship voyages.

Considering that each bin weighs approximately 1.5 tons, a total of 732 tons of dry waste were brought over to Tynes Bay for incineration in one season.

Every ship differs in the amount of dry wastes produced, as some have their own incineration plants on board, and burn wastes while at sea. Norwegian Majesty for example does not unload any wastes in Bermuda, but in Boston.

Total amount of dry wastes brought to Tynes Bay Incinerator plant from the cruise ships on a seasonal basis amounts to approximately 932 tons. This is a relatively small percentage of the total amount of wastes burnt at Tynes Bay on a yearly basis, that is 65,000 metric tons. (Tynes Bay Plant manager, *pers.comm*.)

Recycling was apparently encouraged by Works & Engineering, as cruise ships do not have the capacity to hold recyclables for a long period of time- or for the length of the voyage. In order to avoid disposal at sea, W & E facilitated the unloading of recyclables in Bermuda. Theoretically, the recyclables collected in Bermuda should be the result of the East Coast-Bermuda section of the voyage. When in port, these recylables are collected by private contractors. Cruise ships are charged by private contractors for transport of wastes and recyclables; however, there is no additional charge in order to cover the cost of recycling or any other waste management. Documentation of the total volume of recyclable collected in Bermuda is given below as the number of trucks or containers collected on a weekly basis by the private contractors. **Note:** It is difficult to assess the exact volume of Bermuda domestic collection, as the trucks utilised for collection, are able to almost double their capacity of collection. There is furthermore no weighing table at the Recycling Plant or at Marsh Folly.

Table 5. Collection of recyclables in Bermuda, detailed as no. of trucks/week or no. of containers/week from domestic sources and cruise ships. (W&E officials, *pers.comm*.)

	Volume/week	***Total recyclables***
Bermuda Domestic Collection	10 trucks/ week (4.5 ton truck)	520 trucks
Cruise ship Collection	2 containers/week/ship (18 cubic yard containers)	288 containers/season

The only other estimates potentially available are the number of bails shipped out on a monthly basis. Upon receipt of recyclables, the recycling plant puts recyclables in bails, and ships these bails to the United States. These recyclable consists of compacted alumninum and steel. These are compacted and placed in a 1 ½ m^3 bail; there are approximately 17 bails/container. On the average two containers a month are shipped to the United States- i.e. a total of 34 bails, amounting to a volume of 612 m^3 /year (W&E official, *pers.comm*.). According to the plant manager at Tynes Bay, a total of 10,000 metric tons of recyclable are sent off per year from Bermuda. W&E officials feel that the percentage of recyclable from cruise ships is high and has a large impact on the recycling plant of Bermuda. There is present concern to minimise this impact in the future years.

V. CORAL REEF SEDIMENTATION

Sources: Dr. R. Smith (BBSR), scientific literature

Sedimentation from dredging and run-off constitutes one of the biggest potential sources of reef degradation from human activities in the Caribbean and in the Pacific (Rogers, 1990). Dredging near coral reefs and accelerated runoff of eroded soils increases turbidity, thereby cutting down light available for photosynthesis, as well as increasing sediment load on corals. Sediments settling on coral colonies or causing high turbidity while suspended in the water column have sub-lethal and lethal effects. Sediments are less likely to cause a problem when strong currents are present. Decline of tropical fisheries, evident for the Caribbean (Rogers, 1985), is partially a result of degradation of coral reefs, seagrass beds, and mangroves from sedimentation. Increases in sedimentation rates can also alter the interactions between organisms and their habitats. Juveniles of many fish species and other organisms depend on mangroves and seagrass beds for food and shelter, moving to deeper waters and offshore reefs as they mature. Deterioration of any of these ecosystems can lead to a decline in fish populations. For example, cutting of mangrove trees which normally entrap sediments can result in excessive siltation for nearby seagrass beds and reefs from runoff after heavy rains. Excessive

sedimentation can affect the complex food web on the reef by killing not only corals, but also sponges or other organisms which serve as food for commercially important fish and shellfish.

A study has been compiled by Waltham (1997), considering the effects of shipping traffic on adjacent coral reefs along the North Shore of Bermuda. While many studies have been undertaken to look at the effects of sedimentation near reefs influenced by dredging operations, or by terrestrial runoff, none have focused on ships as a potential source of sediment loading on coral reefs. Cruise ships passing through the shallow south channel in Bermuda create plumes of suspended material which may settle on the adjacent reefs, or increase turbidity in water column. In the last decade, these ships have become large in size, and more frequent in visits. About 4-5 ships pass through the channel per week; this compared to about 1-2 ships per week in the 1950 and 1960. Large ships have a greater propwash which in turn increases the amount of sediment being resuspended from the sea floor. The investigation was to measure sediment deposition rates and water column turbidity at each of the four study reefs along the North Shore and determine if coral coverage for both the control and impact reefs had changed significantly from 1993-1997.

Sediment deposition rates were monitored on four reef sites along the North Shore, from September 1996 to August 1997. The two control sites were located <100m off North shore, approx. 500m east and west of Tynes Bay. The two impact sites were about one kilometre offshore from Tynes Bay, adjacent to the south shipping channel. Sediment deposition rates were significantly higher at the impact reefs during the summer months than the control reefs. This increase was attributed to ship activity causing resuspension. However, fall and winter storms appeared to have a greater effect on sediment flux rates than ship activity. Turbidity was recorded on and off the study reefs and additionally in the channel and at the reefs, before and after the passage of a ship. A significant increase in turbidity was recorded in the channel after the passage of a ship. The conclusion of the study was that whilst ship activity in the south channel may be elevating sediment deposition rates during the summer months, the adjacent coral reefs do not appear to be negatively impacted.

Upon discussion with Dr. Smith, Waltham's supervisor, some limitations to the study were outlined, suggesting the need for further research. Although winter storms may cause elevated levels of sedimentation, it is difficult to differentiate whether elevated cruise ship sedimentation provides additional stress during the summer months, when temperature are highest. Furthermore, the distance of travel by a plume formed following the passage of a ship has not been assessed; it is therefore difficult to ascertain whether these plumes reach adjacent coral reef patches or not. High levels of short pulse sedimentation during periods of high temperature, may have a different effect on coral reefs than longer pulses of a lesser level during periods of colder temperatures- as for winter storms.

It is also worth noting that coral coverage may not be the most sensitive method for assessing the health of the coral. The growth of a coral skeleton is slow, and is the end result of several physiological processes which can be altered by environmental conditions. Coral growth does not appear to be a simple indicator of excessive sedimentation, as outlined by others (Rogers, 1988). Growth can vary greatly between colonies of the same species under similar environmental conditions and even within a single colony. This variability makes interpretation of results difficult.

There is one further point and that is the contribution of patch reefs in the North Lagoon to the overall recruitment for Bermuda's outer reefs is not known. This implies that the health of the patch reefs may prove vital to Bermuda's reefs in general.

The issue of coral sedimentation may also be of concern during the potential widening of the

shipping channels to accommodate future super cruise ships. Little information has been made available to date on the requirements for widening channels by the Consultant Planning & Engineering firm hired by government; it is nevertheless a question which should be addressed in order to assess any potential impact to adjacent coral reefs.

Field and laboratory scientific studies provide one of the best tools for assessing such an impact as described above. According to the scientific literature, further research is needed on the threshold levels for individual reef species- i.e. levels above which sedimentation has lethal effects for particular species and above which normal functioning of the reef ceases. What turbidity level will result in a given percent decrease in the amount of living coral cover? What sedimentation levels cause death of coral species in the field? Normal sedimentation rates for coral reefs appear to be on the order of 10mg/cm2/day or less, and typical suspended solids concentration are less than 10mg/l. In Bermuda, maximum sedimentation rates were calculated to be in the order of 5.65 mg/cm2/day (Waltham, 1997). But how high can these concentrations and rates go before reefs and reef organisms are adversely affected. Bermuda's environment is known to be one where tropical species, including corals, are living at the limit of their tolerance range. Is increased sedimentation causing an additional stress factor, which may in turn lead to a long term impact on the coral reefs? Are short-term acute pulses of sediments into the reef environment, as potentially occurs following the passage of a ship, less detrimental than chronic sedimentation at lower levels? Or vice versa, are short-term acute pulses of sediments combined with high summer temperatures, more detrimental than sedimentation at lower levels during minimal winter temperatures? Ideally, research should be designed to provide a basis for predicting the response of coral ecosystems to known inputs of sediments into reef waters from coastal development.

In light of the above questions raised, it follows that turbidity measurements in the water column performed during and post a ship's passage may prove useful in the assessment of suspended sediment transport, and consequently on the potential impact to adjacent coral reefs. Furthermore, a model predicting the effect of new propellers for super cruise ships (section I.4) on the resuspension of sediment- in terms of distance plume traveled, and time period in suspension- may give further insight into the potential impacts on surrounding ecosystems in future years. Monitoring of the reefs, adjacent to the shipping channels in terms of coverage, will be continued by BBSR.

VI. THE POTENTIAL IMPACTS OF DREDGING

Sources: Dr. D. Connelly (BBSR), Research Technician F. McCarthy (BBSR), scientific literature

Generally, impacts of dredging may be classified as:

A. Physical Impact- where there is physical destruction of the environment, as well as sedimentation and siltation causing the blocking of light in the water column. The extent to which both sedimentation and siltation occur depends greatly on the fraction of silt present in the dredged sediment, as well as on the currents in the water column and at the surface of the sediment bed. This in turn affects the distance of plume transport, created by dredging, as well as the time taken for settlement of the plume (or suspended sediments). It is explained in further detail below:

A higher fraction of silt will carry the plume a longer distance than a coarser sediment, and will take a greater time period to settle. The movement of dredged sediment may be reduced by the use of curtains; the extent to which it is reduced is once again dependent on the fraction of silt.

Sand grain analyses have been performed for Hamilton and St. George's Harbour, determining the fraction of fine silt in those sediments. Results showed that there is a very high portion of silt in Hamilton Harbour, unlike St. George's (Connelly, 1998). Within Hamilton Harbour, the areas with highest proportion of the smaller sediment fraction (<63 microns) in Hamilton, were either close to the shipping channels, in the deeper areas of the Great Sound Basin, or in the inner harbour area. This reflected the effect of shipping on the sediment character. Ship activity tends to resuspend the sediments in the area. Gravitational forces cause the heavier particles to settle first, and the lighter, smaller particles make up a majority of the surface sediments.

From this work, it may be expected that the plume of transport following dredging, will be larger in Hamilton Harbour than in St. George's Harbour. Although the marine fauna and flora of inner Hamilton Harbour is scarce, and there is apparent little cause for concern in this harbour, uncertainties on the distance of plume transport render the assessment of potential impact on surrounding ecosystems difficult. Although, tidal flushing both in Hamilton Harbour and St. George's Harbour may be of benefit to the dispersal of resuspended sediments, the lack of data on currents in the water column and off the sediment bed in these inshore waters is an important unknown which should truly be ascertained prior to dredging.

The concern therefore lies not only on the impact potentially created on the portion of marine ecosystem which is actually removed, but more so on downstream areas where currents carry increased concentrations of fine suspended particles. It has been found that continual resuspension and transport of dredged sediments can cause reef degradation years after dredging ceases (Rogers, 1988). It is not only reefs, but the whole ecosystem which may be impacted; for example, studies on the effect of siltation on spiny lobster recruitment in the Florida Keys, have concluded that the relative lack of juvenile lobsters in heavily silted areas was a result of both lower post larval settlement and actual avoidance of algal habitats with high silt loads. (Herrnkind et al., 1988).

B.Chemical Impact- where chemical reactions normally occurring in the sediments are altered following dredging, thus allowing for the release of certain compounds into the water column, which may in turn affect the surrounding ecosystem. These processes are explained in greater detail in the following paragraph:

Under normal circumstances, reducing conditions exist in the sediment. During dredging, reduced pore waters are released in the water column. In this way, some metals become available, especially those associated with carbon; this occurs following the carbon dissolution in the water column, thus freeing the associated metals. These metals include copper (Cu), and manganese (Mn). It is argued as to whether lead (Pb) is released in this way. It is well known that high levels of copper in the water column may be toxic to marine organisms at various stages of their life cycle, inhibiting, growth and reproduction. There is furthermore, indications that manganese has a negative effect on fish, reported in scientific studies elsewhere (Simkiss, 1996). Studies have also been conducted on the role of mangroves in heavy metals cycling; these may either act as long-term sinks for metals by immobilizing them in sediments, consequently decreasing environmental risks, or b) deposited metals may be remobilized through plant uptake and eventually exported with plant detritus, increasing the possibility of metals entering coastal food chains. Dominance of one process over the other seems to be dependent upon local environmental characteristics and metal species (Lacerda et al., 1985).

The concerns outlined above in A. and B. not only relate to the dredging of Harbours for upgrading of berthing facilities, but also to the associated requirements for widening of the shipping channels, as well as to the routine movements of ships from one port to the next causing continuous resuspension of sediments.

C. Disposal of Dredged Material- where a site needs to be selected for the disposal of a substantial amount of material obtained from dredging. This material may be used for landfill if need be, or is disposed of in the marine environment in a chosen site. Some problems may arise from the latter, explained in the following:

Depending on the composition of the sediments- i.e. on the concentrations of trace metals and organic pollutants found in the dredged sediments-, the site of disposal becomes a crucial issue. For example, if the site chosen is found to be high in sediment associated trace metals and organics, there is a potential for a compounded effect of pollutants from the dredged material and from the disposal site, yielding high values of contaminants in the resulting sediment. Historically, there have been two sites for disposal of dredge material in Bermuda: Granaway Deep, and the Great Sound. Although as outlined below, there has been extensive work on trace metal analysis of sediments in Hamilton and St. George's Harbour, There is no data for trace metal levels in Granaway Deep sediments. The addition of dredged material from Hamilton Harbour to this site may compound the levels of trace metals in Granaway Deep sediments. Furthermore, there exists no data on the concentration of organic compounds in the sediments of the inshore waters mentioned above.

Scientific Work:

Trace metal levels have been determined for the sediments of Hamilton Harbour and St. George's (Dr. D. Connelly, BBSR). Concentrations of lead, copper, cadmium, nickel and manganese were determined in 32 separate locations in the Great Sound/Hamilton Harbour basin, in 1997/1998. For all of the metals, the trend seen was an increase in metal concentration towards the inner Hamilton Harbour area. These are relatively high compared to other sediments in Bermuda. There are at present no criteria in Bermuda for trace metal concentrations in marine sediments. These are however being developed at present. Canada is one of the few countries with these types of guidelines. They are defined as followed:

1) assessment level- defines the concentration of trace metal where caution is advised.
2) remediation level- defines the concentration of trace metal where action must be taken to avoid further toxicity.

Future Work:

The Ministry of the Environment has commissioned BBSR (Dr. A. H. Knap) to develop guidelines for minimising the potential impact from dredging activities planned for Hamilton and St. George's harbours. This will also include sampling guidelines and apolicy on disposal of dredge spoils. These guidelines will closely follow those outlined in the London Dumping Convention (1975) to which Britain is signatory.

In brief, The London Dumping Convention (LDC) states that:

Evaluation of the physical characteristics of sediments for disposal is necessary to determine potential environmental impact and the need for chemical and/or biological testing. The basic physical characteristics required are the amount of material, particle size distribution and specific gravity of solids. In Bermuda, both the physical and chemical characterizations of the dredged material can be acquired for the most part from existing reports at BBSR, except for organic content as mentioned previously. The LDC states that biological testing need only be conducted should the potential impacts of the dredged material to be dumped cannot be assessed on the basis of the chemical and physical characterization and available biological information. It is important to ascertain whether an adequate scientific basis exists on the

characteristics and composition of the material to be dumped and on the potential impacts on marine life and human health. In this context, it is important to consider information about species known to occur in the area of the disposal site and the effects of the material to be dumped and of its constituents on organisms.

It appears that considering the updated plans presented by the Consultant firm on March 4, 1999, dumping of dredged material may not be an issue. As outlined in section I.5, it was suggested that the dredged material be utilised as landfill, namely for Hamilton. However, this has not been ascertained.

It does appear that there is a lack of available data allowing an evaluation of the distance and time period of plume transport following dredging at either site. The planned activity of dredging in addition to potential increased sedimentation from cruise ship movements may require a more rigorous comprehensive research to quantify the response of individual reef organisms and the reef system as a whole to sedimentation. Multidisciplinary studies may be the best tool for understanding the effect of increased sedimentation on the structure and function of coral reefs and associated marine ecosystems. Long term data sets are a necessity for these complex ecosystems. The interactions and linkages among mangroves, seagrass beds, and coral reefs require further study. Lastly, the sheer destruction of the physical environment, as resulting from the planned expansion of Town Cut warrants a thorough assessment of the value of the berthing of cruise ships in St. George's itself.

VII. ANTIFOULING AND LEACHING OF CONTAMINANTS

Sources: Dr. D. Connelly (BBSR), The Motor Ship Magazine (January 1999)

Following the lead of the United Kingdom, Bermuda introduced legislation in 1989 aiming at controlling the use of TBT based anti-fouling paints. This legislative measure effectively banned the use of TBT based anti-fouling paint on all vessels less than 25m in length, with the exception of aluminum hulled craft. Container ships and cruise ships which visit the island still use, however, TBT antifouling paint. The reason for this being that TBT is one of the most effective organotin compounds used in antifouling paint. These paints are effective up to 5-7 years, compared to the 3-4 year period for copper based paints.

In-depth studies have been conducted at BBSR analysing concentrations of TBT in the coastal waters of Bermuda. The issue with TBT is that it leaches out of the paint slowly, accumulates in the sediment, in turn re-entering the water column and ecosystem via leaching of the sediments. TBT data was first reported in 1990 in Hamilton Harbour. Concentrations of TBT were found to be as high as 100ng/l in the water column and 237 ng/l in the surface micro-layer. Analysis of faunal composition in Hamilton Harbour taken at the same time as this work implied that the community structure in the harbour was adversely impacted by the high TBT concentrations. Changes in TBT concentrations were reported following the 1989 ban in the Bermuda Coastal zone over a period of 7 years. (Connelly et al, unpublished). These data indicated a reduction of TBT in the water column in Hamilton Harbour since 1988; thus reflecting the ban on the use of organotin based anti-fouling paints, and its effectiveness. The inner harbour area with an initial high concentration of TBT in the water column underwent the most dramatic reduction.

However, the concentrations of TBT in Hamilton Harbour are still above the EQS concentration selected by the U.K. (2 ng/l). Since the calculated half-life of TBT in the water column has been determined to be in the range of 7-15 days, there must currently be sources of TBT to Bermuda waters, to justify the levels analysed. The continued presence of TBT in the water column can be explained by either:

1) Continued " illegal" use of TBT based paints- Illegal use of TBT based paint would be reflected in higher concentrations of TBT in the inner Hamilton harbour area than in the other more open areas; as this is not the case, the illegal use of TBT by smaller vessels in Bermuda is ruled out.

2) High concentrations of TBT leaching from permitted vessels (cruise ships and container vessels)- The high concentrations of TBT at the other stations in on close to shipping lanes used by cruise ships and container vessels, indicated that these vessels, exempt from the legislation, are a potential source of TBT to the Bermuda Coastal area. This was especially true for the Hamilton area. However, low concentrations of TBT were analysed in the water column in St. George's Harbour. This Harbour has large vessel traffic only during the summer period, and the low concentrations of TBT in the water column in this area were explained by the flushing of this area with offshore unpolluted waters.

3) Sedimentary inputs- Sediments have been cited in other reports as being a source of TBT to the overlying water column. TBT can enter the water column via desorption following sediment re-suspension events. Estimates for the breakdown of TBT in sediments range from months to years. The very high concentration of TBT found close to the boatyard probably represent historic inputs of TBT, either due to desorptive processes fom the sediments or run-off from the boatyard. Boatyard activities would have been responsible for a build up of TBT in this area. The sediments in this area contained visible paint chips and scrapings. At the present time the importance of the sediments as a source of TBT to the overlying water column in Bermuda is unresolved.

Manufacturers are investigating other options than the use of TBT. In order to increase the efficiency of copper based anti-fouling, manufacturers have started adding herbicides to the paint formulation. One such additive is the triazine herbicide 2-methylio-4-ter-butylamino-6-cyclopropylamine-s-triazine (Irgarol 1051). There is growing scientific concern that there may be deleterious environmental effects associated with the introduction of this novel compound into the environment. Concentrations of Irgarol 1051 measured in Hamilton Harbour by BBSR were in the range of 23.4 to 56 ng/l. The presence of high concentrations of Irgarol 1051 and low concentrations of TBT in the Harbour indicate that smaller vessels are now using copper based paints with Irgarol 1051. The high concentration of Irgarol 1051 in the vicinity of the boatyard (592.2 ng/l) is further evidence for the wide spread use of anti-fouling paints with herbicides. The potential toxic effects of Irgarol in marine environment's has not been studied in any detail; however, concentrations of Irgarol measured near the boatyard in Hamilton are a cause for concern.

Future Objectives:

The IMO has approved a draft Assembly resolution including a deadline of 2008 for the complete prohibition of organotins acting as biocides in antifouling. These plans are worrying owners' organisations, such as the International Chamber of Shipping, because they believe that there has been insufficient research carried out into the effects on the environments of the copper-based replacement paints. Copper-based replacements are not as effective as TBT. Most vessels have a dry-docking interval of five years, and although interim surveys are required every two-three years, these can be carried out in-water. If the maximum overcoating intervals quoted for the replacement paints are three years, this means ships need to be dry-docked more often, involving extra costs. The ICS and other organisations are urging governments to conduct research into the alternatives, and have these finding on the table before considering the adoption of an instrument of prohibition. Manufacturers charge twice as much for tin-free paint as for TBT. There is worldwide concern on the potential toxic effects of Irgarol in marine environments. The potential banning of TBT in the years to come render this a dying issue; however, studies are required for the long term impact assessment of Irgarol 1051 in Bermuda's marine environment.

VIII. DOCKSIDE CLEANING

Sources: Registry of Shipping Officials, Ministry of Environment Officials, Dr. D. Connelly (BBSR)

There is at present no legislation regarding the dockside cleaning of ships in Bermuda. During this process, there exists a release of detergents and cleaning agents from the ships; furthermore, the scrubbing of ships releases copper and TBT into the water column. As documented in a BBSR study cited in the previous section, paint chips were found in abundance in the harbour sediments. The only legislation pertaining to this issue in Bermuda is the Water Resources Act; which may be summarised as "Thou shall not pollute the inshore waters". It is an Act which provides few specifications, and which has only recently included small vessels, but excludes ships. The Department of Marine & Ports does not have any regulations concerning dockside cleaning of cruise ships. Truly, the issue of putting contaminants into the water column through dockside cleaning or other processes is not one solely concerning cruise ships, but also one concerning small boats, boatyards and marinas. In the U.S. guidelines are set by the EPA and used as preventive measures to minimise impacts resulting from dockside cleaning.

An example of guidelines set by the EPA, namely for marinas, are given below.

a. Wash the boat hull above the waterline by hand. Where feasible, remove the boat from the water and perform cleaning where debris can be captured and properly disposed of.
b. Detergents and cleaning compounds used for washing boats should be phosphate-free and biodegradable, and amounts used should be kept to a minimum.
c. Discourage the use of detergents containing ammonia, sodium hypochlorite, chlorinated solvents, petroleum distillates, or lye.
d. Do not allow in-the-water hull scraping or any process that occurs underwater to remove paint from the boat hull.

The above guidelines are set by the EPA, but are controlled through the Clean Water Act (CWA) part of which aims to eliminate the discharge of pollutants into navigable waters. The extent to which dockside cleaning of cruise ships occurs in Bermuda is not certain, nor is the impact on the surrounding ecosystem evaluated. However, there appears to be little action taken on the prevention of pollutant discharge in the inshore waters (except for that concerning

oil spills) of Bermuda. It therefore seems that in order to protect the chemical, physical and biological nature of Bermuda's marine environment, investigations into the benefits of more adequate legislation may prove useful.

IX. DISPOSAL OF OIL-CONTAMINATED BILGE WATER.

Sources: Marine Police, Dr. D. Connelly (BBSR), Department of Marine & Ports, Ministry of Environment.

Bilge water is a mixture of oil and fresh and/or sea water. It may also contain cleaning agents and other additives used during normal ship operations.

According to Marine Police, the number of incidents reported as oil spill average once a week. 99% of these incidents are a result of heavy rain, affecting pumps on small boats, and allowing leakage of fuel. Usually, this results in a gasoline sheen on the surface of the water. These incidents are accidental, and more of a nuisance than an environmental problem.

As for cruise ships, Marine Police claim to have a good rapport with the boats, and usually meet with the Agents and the skippers at the beginning of the season to notify them of Bermuda laws in terms of bilge water dumping, oil dumping and general pollution of the marine environment. Marine Police relates that cruise ships skippers are usually very aware of the environment and of the potential impacts caused by such activities. Ships have their own policy for the management of ship-generated waste, as well as their own spill contingency plans with on-board booms in case of an accident. A copy of the Royal Caribbean Cruises Ltd. plan takes into account the responsibilities of each official in the ship, practices allowed at sea, and those allowed in port, and lists the categories of ship generated wastes , as well as the procedures followed for each (see Appendix Section). Below is the procedure outline by RCL for disposal of bilge water:

"Bilge water is to be collected and stored only in the designated tanks. No other tanks are to be used for this purpose.

Port Condition: All bilge water shall be kept on board or pumped to an adequate reception facility.

Sea Condition: Bilge water which has been processed through the bilge water separator and does not exceed 15ppm of oil as measured by the monitor in the system may be discharged overboard. If the monitor is inoperative, no processed bilge water may be discharged overboard. The skin valve for the bilge water separator discharge shall be kept locked except when pumping is authorized by this policy. The Engineering Officer of the Watch shall maintain control of the key. The time and ship's position of each starting and stopping of discharge and the quantity discharged from the bilge water separator shall be recorded in the Oil Record Book. The bilge water separator monitor shall have a continuous recorder and shall alarm in the engine control room if a measurement in excess of 15ppm is recorded. The alarm shall be visual and audible."

Should there be an accidental oil spill, boats are asked to notify the Marine Police immediately. Marine Police states that most ships ask their agent to notify the authorities as soon as a spill is observed. Failure to notify the authorities can lead to prosecution; it is the Agent which is prosecuted and not the Master. The penalties usually consist of a fine, and the boat is charged with the clean up of the oil spill. Boats may be detained in Bermuda, until there has been clearance of the agent's insurance to be responsible for the clean up. There is therefore a long legal road to follow should there be an oil spill. The Marine Police is very aware of the mangrove communities in Hamilton Harbour near the shipping lanes, and strictly applies the existing strict regulations and rules. These rules and regulations follow those outlined by

MARPOL. By law, officials are allowed to board and inspect the ship any time, under the Oil Pollution Act. According to Marine & Ports, approximately 15% of the visiting cruise ships are inspected.

There have been spills in the past, and currently (Feb 99) two boats are being taken to court following oil fingerprinting by BBSR scientists. One of the two ships is a cruise ship, the Royal Viking Sun. Spills reported in Bermuda up to date, while ships are in port, have been of accidental nature. These accidents have always been well managed by Bermuda, since a Pollution Prevention Plan, including an oil spill contingency plan exists. This has proved to be a very adequate according to all involved.

The above related strict measures apply to ships in port. There has been however serious incidents concerning contaminated bilge water dumping in the ocean by the same cruise line in other parts of the world. According to Marine Police however, the law in Bermuda does provide the tools for controlling and regulating these acts in Bermuda waters. It is uncertain as to the enforcement of these regulations when ships are out of port but still in Bermuda's territorial waters.

X. EMISSIONS FROM CRUISE SHIPS

Source: Dr. K. Simmons (BBSR), Ministry of Environment, Bermuda Water Consultants

For any ship coming into Bermuda, the Ministry of the Environment requires an emission permit; such that all ships have to put in an application for a license to operate a controlled plant whilst in port. In the application, the type of plant, general purpose, size and capacity, type of raw materials and fuel used, and the type and amount of chemicals or processing materials used is described. A description of the effluent stream, including manner and method of effluent discharge from the plant, stack height, rate of release, and temperature are outlined.. Finally the type of air pollution control device is shown, and a contingency plan available for pollution control in the event of mechanical failure. The annual license fee is currently $52.00 per plant. Questions relating to the concentration of air contaminant and monitoring of air quality are posed. Ships with incinerator plants, desiring to burn papers, plastics and dewatered food waste in port need apply; as well as for the running of boilers, engines for their generators, according to the Clean Air Act. The number of hours the plant will be running in port is also given. Hours of operation vary from 340h/week (Norwegian Majesty) to 79 h/week (Zenith).

Soot emissions occur in port when ships are starting engines for running of generators. When the soot is very dense, it reflects an inefficiency of operation. Emissions consist of suspended particulate matter, and of noxious gases, such as nitric oxide, sulfur dioxide and nitrogen dioxide, as well as organic contaminants. Table 5 gives an example of the type of emissions put out by ships in general. It is the Department of Marine & Ports which have environmental regulations for the control of emissions in port, in Bermuda.

Table 5. Typical emissions from a modern two-stroke engine, taken from "The Motor Ship", January 1999. These specifics are from the Wartsila NSD.

Pollutant	*Mass (g/kWh)*
Nitrogen	6,200
Oxygen	1,100
Co2	500
Water	200
NOx	17

SOx	13.6
Particulates	0.6
HC (soot)	0.4
CO	0.4

Following complaints by Dockyard Marina Members on the amount of " soot" covering the boats, ambient air quality measurements were made in dockyard in 1996; this work was performed by BBSR in response to an enquiry by the Ministry of Environment. Unfortunately, the timing of events was such that soot emissions were finished by time of sampling. Furthermore the winds were not blowing in the direction of the marina on the sampling days and there was no problem at the time. Usually, samples collected are analysed for total suspended particulates, and for sulfur dioxide concentrations. Concentrations at time of sampling averaged to be less than 5 ppb of sulfur dioxide; much lower than the Bermuda Air Quality Standard of 170 ppb. It is to be noted that the amount of soot required to dirty a boat, is much lower than the air quality standard of Bermuda. The Clean Air Act identifies the standards; these are much stricter than those followed in the U.S. according to Dr. K. Simmons, for certain parameters.

Ambient Air Quality Measurements have also been taken at Harbour Radio station, Fort George Hill, in St. George's, in 1995. Once again, these were conducted following complaints from residents in the area. Cruise ships berthing at St. George's on a weekly basis during the summer have on a number of occasions produced smoke stack emissions which impact the local area with black soot and noxious gases, in particular the houses on the Fort George Hill. The Ministry has responded by conducting air quality testing at the Harbour Radio Station on Fort George Hill in order to assess the extent of the problem. Measurements were made to determine sulfur dioxide levels. Results indicated that the highest 1 minute averages ranged between 9ppb and 38ppb, occurring with easterly winds. Local Bermuda air quality standards dictate that mean SO_2 levels not exceed 172ppb in any 1 hr period, 57 ppb in any 24h period and 11 ppb over the course of one year.

The long term effect of soot accumulation on the roofs of residential houses, and subsequent accumulation in domestic water tanks is not known. There is no data on the percentage of soot accumulating on roof tops, namely in St. George's as surrounding area of Hamilton consist mainly of businesses. It may be appropriate to first assess the amount of soot deposition on roofs. The sources of deposition in Hamilton are:

1) Belco, 2) Vehicle emission and, 3) Cruise ship

St. George's and Dockyard have fewer cars, and cruise ships remain potentially the main source of soot on residential roofs. Dr. Simmons noted that the prevailing winds during the summer months appear to blow any emissions from cruise ships berthed in dockyard, towards the North Lagoon, bypassing many of the roofs. Although there exists inspections by Public Health Officials on the quality of drinking water for commercial establishments, such as Hotels, water dealers, etc., there is little available for the protection of human health drinking water for the domestic sector. Guidelines do exist in Bermuda for drinking water parameters, recommending, for example, that water tanks be cleaned every 3-4 years; however, it is not always the case. In a tank left in such a state, sediments become the main source of organics and trace metals, as these accumulate over time. Some water testing in residential water tanks is performed on demand by BWC. The tests include analyses of Pb, Cd and Ni sampled from the water itself in the tanks. In general, the trend is towards low levels of metals in the water samples, namely due to the high pH of water itself. High levels of these metals are however found in the sediments of tanks. As fossil fuel burning does contain organic pollutants, these

organics are found in sediments of water tanks; organic pollutants are not water soluble. These organics and trace metals may be released from the sediments into the water column, following stirring of the sediment, as occurs when water is transferred from a truck into a tank. The EPA (Environmental Protection Agency) has limits for both organics and trace metals in drinking water in the U.S.

At present, there is an Air quality programme which has been conducted by Dr. K. Simmons at BBSR for the past 5 years?. Analyses yield a database on the air composition collected at several sites in Bermuda; unfortunately, as this study was not designed to consider impacts of cruise ships in particular, none of the current sites reflect potential cruise ship emissions. It may be of use to incorporate one more site into this study, providing some indication of smokestack emission by cruise ships, hence evaluating whether or not there is a potential problem relating to this issue.

Future work:

The Ministry of the Environment has commissioned Dr. K. Simmons from BBSR to perform a computer simulation that models smokestack emissions of the cruise ships that visit the island. This study is performed mainly for Hamilton Harbour at the present time; it is however expected to encompass Dockyard and St. George's, as well as providing a model for the emission produced by new super cruise ships.

There has been no constant monitoring of soot emissions and their fall outs in Dockyard, Hamilton or St. George's. All analyses were performed following complaints from residents; the time delay involved in the response did not allow for adequate measurements of the soot emissions observed by complainants in most cases. Furthermore, as seen in the cases outlined above, air quality studies performed by BBSR have analysed for sulfur dioxide in emissions only, such that the concentrations of other contaminants- namely organic compounds- has not been determined. On the other hand, it must be noted that there is a movement in the cruise industry for the use of lower sulfur fuel in cruise ships; such that during fuel burning in port, a lower emission of sulfur dioxide would result, a positive move towards good air quality.

Although the general trend in the design of new ships is a more environmentally friendly one, uncertainties are still present on the long term impact of soot emissions, if any. However, the proximity of residential homes to cruise ships warrants a closer look at soot accumulation on the roofs, and subsequent potential accumulation in the water tanks of both heavy metals and organic pollutants. The lack of regulations on drinking water quality renders this type of work more vital to human health. There seems to be furthermore, a lack of awareness by the general public on the importance of tank cleanliness, although guidelines are present as outlined earlier in this section.

XI. NOISE POLLUTION

Sources: Scientific literature, Department of Tourism officials, Chairman of the St. George's Activities Committee

Noise Pollution is a concern which emerged in recent years as an ever present but often underestimated pollutant in our lives. Traffic noise has been identified as one of the largest sources of noise pollution in Europe. Environmental noise has been shown to affect health and well -being physically, mentally and socially. There is ample evidence showing that high noise levels interfere with speech and communication, cause sleep disturbance, increase stress-related hormones, and blood pressure changes. The two major sources of noise pollution in Bermuda

are undoubtedly traffic and cruise ship entertainment on deck. The latter has been a major source of complaint by St. George's residents.

The issue of entertainment aboard cruise ships while in port appears to be a complex one. The Cruise ship permit in Bermuda prohibits entertainment while in port, in terms of shows, spectacles, etc. This was strictly adhered to until 5 years ago; however, complaints by the cruise ship industry on the lack of night time entertainment provided on the island (namely in St. George's) made way to the provision of music for dancing on board. Department of Tourism officials claims that every year, there is an attempt to restrict the hours and the loudness on deck at the beginning of the season; however, as the season goes on, restrictions appear to slide, to the point of being neglected, such that nightly entertainment on-deck while in Port becomes "acceptable".

The former Minister of Tourism tried to set up a commission with local musicians and entertainers to provide nightly entertainment. It was a difficult task according to Tourism officials; local musicians were said to be difficult to deal with, and offering inadequate entertainment for cruise ship passengers. Tourism officials voiced the need for communities to make an effort towards providing services to cruise ships, in terms of shows, spectacles etc. It may seem therefore that the cruise ship permit may be forbidding the wrong type of shows; in that, it may be hard for Bermuda to initiate and offer large spectacles catered towards cruise ship passengers, it may, however, be more easily manageable by local bars and clubs to provide music and dancing.

Regardless of the complex issue of entertainment for cruise ship passengers, attempting to satisfy their vacation experience, while maintaining a quality of life for residents, there is a law pertaining to noise pollution in Bermuda which is not adhered to by cruise ships. It is law that any noise made during 12am to 6am, which is more than 100' from the source, and annoys more than 2 people is an offense, written in the Summary Offenses Act under Public Health Act (see Appendix section).

The only precedence in taking action against noise pollution by cruise ships occurred in an earlier case; where complaints were made by residents of St. George's on the noise originating from the generator of cruise ships. These complaints were considered seriously by the Ministry of Environment, Tourism and the Department of Marine & Ports. The noise frequency was measured, the problem pinpointed and resolved, resulting in the changing of generators by cruise ships.

Future plans:

The National Transportation Authority is considering noise pollution from vehicles in the development of its National Transportation Plan. There appears to be little consideration for the noise pollution originating from cruise ships. In order to maintain a quality of life for residents in proximity to cruise ships, this issue appears to be one of importance, and in need of being taken seriously into account. Most complaints concerning noise pollution by cruise ships originate from St. George's, reflecting the residential aspect of this Port.

With regards to the Ministry of Tourism's expression on the involvement of communities for the provision of services to visitors on the island, and more specifically to cruise ship passengers, it is known that the St. George's activities committee has been meeting with the Chamber of Commerce to establish a schedule of events for the summer months.

Whether or not these efforts will be appreciated by the cruise ship industry are uncertain, and whether or not these efforts will alter the entertainment philosophy of the cruise ships is doubtful.

The success of a movement towards adequate local entertainment, encouraging cruise ship passengers to attend land-based events and attracting other visitors and locals, does not seem probable without the joint work and support of both Port communities and the Tourism department. This is an issue which should truly be incorporated in the broader concept of a long term tourism plan.

The smallness of Bermuda renders the issue of noise pollution crucial, and should be seriously considered by the Ministry of Public Health under the Public Health Act.

XII. INFRASTRUCTURE/TRANSPORTATION

Sources: Transportation 2000 Report, Bermello-Ajamil & Partners Inc.

At present, there is a 3-year policy for cruise ships, expiring in the year 2000. This policy includes a passenger limit of 6,000 passengers/day. The Transportation 2000 report (1997) summarises the issues relating to transport and infrastructure available for the accommodation of tourists and locals in Bermuda at present. The present document was not to focus greatly on infrastructure, as the Planning & Engineering Consultant firm hired by government was to consider it in detail. Nevertheless, some of the major points were taken from the Transportation 2000 to put the cruise ship issue in perspective.

At the present, Tuesday, Wednesday and Thursdays are peak days for cruise ship visitors. The number of cruise ship passengers in Bermuda on Tuesday, Wednesday and Thursday frequently exceeds 6,200. The ships usually arrive early in the morning on Monday and Tuesday and depart early in the afternoon on Thursday and Friday. The impact of such a high number of cruise visitors arriving on the island at approximately the same time has a significant effect on the Island's transportation service.

An analysis of cruise ship visitor's travel pattern was made by the same report.

In May 1997, approximately 22% of cruise visitors went on tours on Tues., Wed. and Thurs. These tours are marketed and booked on the ships on their day at sea en route to Bermuda. St. George's was the most popular port for shore excursions, capturing 51.7% of the total shore excursions for all cruise ships. Hamilton captured 39% with dockyard attracting 9.3% of the excursions. All shore excursions are handled by agents. Over 60% of shore excursions were water sport related, with 21% being bus tours, and 15% being taxi tours. The water sport providers estimate that 65% -70% of their weekly customers come from cruise ships.

According to industry sources, approx. 10%-15% of cruise visitors rent livery cycles, which is substantially lower than the 30%-40% of hotel visitors that are estimated to rent cycles. The cruise lines discourage their visitors from renting cycles, citing safety and liability issues, and prefer their visitors to take organised bus, taxi or water sport tours, or to use public transport. The transportation passes, introduced in 1992, now account for over 50% of the revenue for the bus and ferry systems. On a typical Tuesday, long queues occur outside of the St. George's, Dockyard and Hamilton Visitor service bureaus for purchase of passes.

While on land, cruise ship visitors tend to travel at the same time of the day. With over 6,0000 cruise visitors on the island on Tuesdays, Wednesdays and Thursdays, the public transport system experiences serious overloads during those times, causing negative perceptions from the visitors, both cruise ship and air tourists. The Public Transportation Board must supplement regular service during those times with additional buses, while certain ferry trips also experience overloads. " We cannot meet the demand on certain days of the week" as the Director of Public Transportation Board was quoted.

The issues on transportation concern lies in part in the fact that "No single group is responsible for transportation decisions in Bermuda"(the Minister of Transport, Transportation 2000 report). Because of this, no attempt has been made to provide a comprehensive and integrated transportation system, with most decisions on policy made independent of the impact on the other transportation providers. Furthermore, protectionism of certain transportation providers has resulted in restricting the options available to the customers.

The Motor Car Act 1951 served the island effectively for many years, and resulted in avoiding or delaying traffic congestion experienced elsewhere. According to the Transportation 2000 Report, however forward thinking the Act was, it is no longer sufficient as the only tool for controlling the increase, and the influence of the motor car.

Sections 1-8 of this report indicated some of the transportation related issues that exist in Bermuda today. Unless action is taken to seek a change in direction, the Island faces the same traffic related issues that have been experienced in major metropolitan areas throughout the world. Unlike many of those areas, Bermuda has no place to expand. Indeed, the quality of life that makes Bermuda unique is at jeopardy unless action is taken to improve the transportation infrastructure.

Future Actions:

Bermuda has a high density population (one of the highest in the world), sharing a small land mass. Quite simply, Bermuda does not have space, and the little there is needs to be efficiently utilised. The architects of the Motor Car Act in 1951, stated that the purpose of the Act was " to preserve as far as possible the amenities of Bermuda". That statement is even more true today.

Bermello- Ajamil & Partners Inc. hired by government to consider new berthing facilities for Hamilton and St. George's claims to integrate the needs of both sites in terms of bus systems, ferry systems etc. The main concern of the Consultant Firm relating to this issue is optimising passenger flow from cruise ships to buses/ferries/taxis terminals; further issues raised by increased number of vehicles on the road, and congestion in shore destinations upon arrival of taxis, ferries, etc., is not considered by this firm. It is not certain that this is considered by any group at this time. Concern from the St. George's corporation on the handling of volume of people raises issues on location of bus terminal, location of selling bus passes, sanitary areas, and improved ferry systems. It has been suggested that water taxis link Penno's wharf and Ordnance Island, and that the bus terminal be located towards Penno's wharf. According to the chairman of the Sanitary committee for St. George's, plans are on the table for such infrastructure improvements, as well as for increased number of public restrooms, etc. It must be noted that a preferred shore excursion as St. George's needs to consider not only the number of passengers from the cruise ships berthed in St. George's, but also those arriving as a result of shore excursions. Furthermore, the residential aspect of St. George's raises different questions as to those raised for example by the use of Dockyard or Hamilton as a cruise ship port. Such that it appears of importance to take into account the individual characters of each port town, and in the same token, the extent of linkage between the individual corporation's plans for their boundaries and the plan to be designed by the hired Planning & Engineering firm is uncertain.

It was not originally planned to incorporate Dockyard in the upgrading of new supercruise ship facilities report to government. However, during the preparation of this document, changes have been made and Dockyard is now taken into account in the study of Bermello-Ajamil & Partners Inc.

The Transportation 2000 Report submitted in 1997 to government recommended an integration approach to transportation planning, where a national transportation plan should be developed. This plan is now being considered, attempting to develop and regulate an integrated, on-island transportation system for visitors and residents.

In conclusion, the increased number of cruise ship passengers at any one time, the limit of number of passengers/day, the flow of passengers from cruise ship to transport mode, the congestion on the roads and at preferred touristic destinations, the available facilities including sanitary, transportation, and finally the historical preservation of some of the Port destinations are all issues in need of being evaluated in order to maintain Bermuda's amenities.

XIII. REVENUE FROM THE CRUISE SHIP INDUSTRY IN BERMUDA

Sources: Department of Tourism, TGG Magazine, Cruise Ship Agent, Tourism literature

Caribbean nations are starting to question the benefits from the cruise ship industry, and the long-term impacts on the region's own land-based tourism. Following a row, in 1993 over head tax, the Caribbean countries realised the inability of the region to take a unified stand, as well as how powerful the cruise industry's grip was. The cruise ship lobby is very strong, governments need to be strong to keep control over this growing industry. As the President of the Barbados Hotel Industry said: The Caribbean will not realize the cruise business is a disservice until it's nearly too late. The cruise ships are using our most precious asset- the sea, and not making any significant contribution to our economy.

In Bermuda, as in the Caribbean, compared to the hotel industry and their guests, the cruise line industry hires no local employees and therefore pays no payroll tax. The cruise line industry pays no duty on supplies, nor do they purchase any energy. The cruise lines pay no occupancy tax, no company fees, and make no social insurance contributions. A Review Committee was set up to seek a way to have the cruise industry make a more meaningful contribution to our tourism industry's economy. This resulted in the installment of an annual Permit Fee. The permit Fee is of $4 per berth, per night in port, in season, and $2.00 per berth, per night in port off season. The fee will increase each year thereafter by $1 per berth.

Revenue from cruise ships is obtained from:

1) Passenger expenditure
2) Services fees to Marine & Ports
3) Dock fees to Corporations
4) Passenger tax

Although cruise ships pay fees for utilising sewage facilities, these are not included as they barely cover the cost involved in processing as outlined in section III.1, and could not be truly qualified as revenue.

1) Passenger Expenditure-

Although, it is written in the Bermuda cruise ship contract that promotions will be made on board the vessel during each of the said cruises for the shopping and recreational opportunities, cruise ship passengers do not appear to spend as much money on restaurants, and shopping than air passengers. Surveys have been performed by the Ministry of Tourism by giving a questionnaire to departing visitors, both at the air terminal and for cruise ship passengers. These surveys attempt to assess the vacation experience of the tourists, and the expenditure during their stay. Results of these surveys are given in the following two reports:

1) Archer Report

2) Cruise ship Expenditure Report.
It was concluded that in general, air passengers tend to outspend cruise ship passengers on a ratio of 10:1. More specifically, in 1997, the total cruise ship passenger expenditure was of $40.8million. Cruise ship passengers spend approximately $245/person, during their stay, including shopping/transportation/ and restaurants. On the other hand, in the same year, air visitor expenditure was of $447.5million. Table 6 provides the breakdown of these expenditures. It must be noted that accommodation is a large portion of the total sum (65%), which should be excluded from comparisons with revenues brought forth from cruise ship passengers.

Table 6. Air passenger expenditure in Bermuda in 1997. (taken from the Archer Report).

Type of Expenditure	*Amount spent in dollars*	*Percentage of total expenditures*
Accommodation	290.88 million	65%
Food/Restaurants	52.36 million	11.7%
Shopping	40.28 million	9%
Transportation	24.61 million	5.5%
Entertainment	13.43 million	3%
Sporting Events	11.19 million	2.5%

2) Service Fees to Marine & Ports.
Cruise ships pay a service fee to Marine & Ports, for such services as that provided by the pilots for example; the total fees paid amount to approximately, $8,000 - $10,000/ship/week. With a total of 36 cruise ship trips coming into Bermuda during the season, the total fees to Marine & Ports are in the range of $288,000 to $360,000 per season.

3) & 4) Dock fees and passenger tax.
According to the Meyer Shipping Agent, Captain John Moore, ships pay in the order of $150,000/ship/trip for various charges. These include docking fees and passenger tax. Docking charges are based on the length of the ship; such that the charge equals the length of ship (meters) x $6.50 x no.of days. An approximate total can once again be calculated on the basis of 36 cruise ship trips a season, yielding $5,400,000 for the season, paid in part to the individual corporations.

The above sections attempt to provide an idea of the revenue brought forth by the cruise ships. It may not be complete, but does give an indication on the comparable revenues brought forth from air visitors and cruise ship passengers. Passenger expenditure for cruise ship visitors is approximately 26% that spent by air visitors (excluding accommodation). The fees charged for docking and passenger tax appear to be of substantial value to the individual ports/corporations; on the other hand, the calculated total for these fees equates approximately 1.8% of the amount spent by air passengers on accommodation. Once again, these figures are estimates and should be regarded as guidelines rather than true values.

According to Department of Tourism Officials, the strongest lobbies for the advent of supercruise ships in Bermuda are:

1) Retail sector- The retail sector claims to make more money off cruise ships passengers; this, however, is not reflected in Tourism report. It must be noted that air passengers have on average a longer stay in Bermuda, hence making interpretation of the

expenditure report tricky.

2) Site seeing operators-
3) Cycle Rentals- This is not reflected in the Transportation 2000 report .

There may be strong lobbies for the push towards supercruise ships in Bermuda, however, the ultimate decision on the size of the ship is the responsibility of the Department of Tourism. This same department is pushing towards week-end cruises in dockyard for this year; the cruise line involved in this is Carnival cruises, with the lowest end of range of cruise ships in terms of quality to be sent to Bermuda. Simultaneously, the Ministry of Tourism is pushing towards eco-tourism and Bermuda as a SCUBA diving destination. It is questionable whether all types of tourism may co-exist on a small island like Bermuda. With the expiration of the present cruise ship policy, a decision must be taken on the direction to be taken by the Ministry of Tourism. Saying no to supercruise ships, is perceived as saying no to the cruise ship industry by certain government officials. It must be noted again, that Bermuda only receives 2% of the worldwide cruise industry; yet this 2% is perceived as being one of the most highly profitable routes for the cruise ship industry; hence, the strong demand for the accommodation of bigger ships. However, will this industry last in Bermuda, or will supercruise ships move towards areas where private islands may be purchased for the ultimate tropical paradise experience? This is a movement occurring more and more in the cruise ship industry. Will the supercruise ship industry destroy the land-base high quality tourism that Bermuda is attempting to market? These questions need to be carefully scrutinized in the very near future.

It is suggested that a complete budget be drawn for a thorough evaluation of the revenues brought to Bermuda's economy from both the cruise ship industry and the land-based tourism, in order to accurately assess the benefits of each. Furthermore, it appears necessary to consider the expenses paid by the island to upgrade facilities for new cruise ships and to calculate the operational costs of these facilities; these expenses need to be incorporated in the overall revenue budget for the evaluation of the super cruise ship industry.

XIV. CONCLUSION

On a final note, it is certain that the cruise ship industry is moving towards larger ships; although it is expected that the ones coming into Bermuda are not the biggest of the lines, they are considerably larger than those presently coming in. Several destinations, and namely those of the Caribbean, are accommodating these new supercruise ships often to the detriment of their marine environment, and to their land-based tourism. This is not done however without disputes, a more recent one ending in the acceptance of cruise operators to demands by Caribbean islands to pay a $1.50 per head "environment levy" on passengers to Grenada, St. Lucia, St. Vincent, Dominica, Antigua and St. Kitts/Nevis (TGG magazine, Sept 1998). This leads to the question of attributing a value to the marine and terrestrial environment of our Island. As seen in the present document, certain compensations are given by cruise ships to Bermuda, as in the event of an oil spill for example; however, in many instances there is little protection of Bermuda's environment. For this reason, adequate laws and regulations are key factors in the control of ship activities, including container ships, cruise ships, and even marinas and boatyards. Enforcement of these laws becomes essential to the preservation of Bermuda's environment. The well publicised case against the Royal Caribbean Cruises indicted with charges of making false statements to the Coast Guard about oily waste discharge in 1994, is a good example of the need to enforce regulations. The greater the number of ship activities, the

greater the potential impact on various aspects of the environment, and the more crucial the development and enforcement of environmental laws become. The juncture at which Bermuda finds itself at present may provide an excellent opportunity to review the overall protection of Bermuda's environment. For, as all groups recognize, tourism can only be enhanced through protection of environmental, ecological and historical resources. By minimizing impacts on the environment, one only ensures the durability of irreplaceable assets which is the very reason for tourism in Bermuda.

LIST OF MAIN POINTS

* The Cruise ship industry is moving towards larger ships, reflected in more than 50 new cruise ships on order for delivery by 2003.

* The present 3-year policy concerning cruise ships in Bermuda expires in 2000.

* The present berth facilities in St. George's and Hamilton Harbour cannot accommodate the new super cruise ships.

* The existing berth at dockyard is physically capable of accommodating a larger ship.

* There is a government proposal to modify the existing berths at St. George's and Hamilton.

* The existing total number of berths available for cruise ships in Bermuda is 5; there is no suggestion to increase the number of berths.

* The present limit placed by the Department of Tourism of 6000 passenger/day was not based on any sound estimate of carrying capacity.

* It is not known whether this limit will be altered with the drawing up of a new policy.

* At present, the WEDCO sewage treatment plant and St. George's sewage treatment plant are heavily impacted by cruise ships; these contribute approximately 50% to the total daily flow of sewage at these plants during the cruise ship season. Hamilton sewage treatment plant is less impacted, as cruise ships contribute approximately 14% of the total flow.

* Dockyard has a secondary treatment plant, with no plans of further expansion. St. George's and Hamilton have a communition plant, where the only treatment is the grinding of solids. There are plans of upgrading for St. George's to a tertiary sewage treatment plant, and for Hamilton to a preliminary treatment plant, and possibly to a secondary treatment plant, depending on results of scientific studies and cost estimates.

* The only existing scientific data conducted with respect to sewage has been performed for the Corporation of Hamilton Sewage treatment plant. Conclusions of the report were based on a 1-year accumulation of data, most probably insufficient to assess a long term impact.

* Environmental criteria, set by the Environmental Authority, are set on a case by case study for sewage plants around Bermuda. Dockyard is the only sewage treatment plant of the three corporations which must meet environmental criteria; there are no criteria for St. George's and Hamilton.

* All information relating to the flow of sewage from cruise ships into the plants is an estimate. There are at present no control or regulations concerning the type of sewage disposed of into the plants, nor the amount.

* Recyclables are collected from some of the cruise ships visiting the island, the total volume of which is thought to be large enough to impact heavily on the recycling plant in Bermuda. There

is no charge to the cruise ships for the processing of recyclable materials.

* There is no accurate data on the total volume of recyclable materials collected from the cruise ships at present.

* There is some scientific data available on the potential impact of sedimentation caused by cruise ship movements on adjacent coral reefs. This issue requires more complex studies than those performed in order to assess the long term impact, especially as new super cruise ships are due to have propellers allowing greater maneuverability and hence create more turbulence, and sediment resuspension.

* Dredging is necessary for the modification of berths in St. George's and Hamilton. Dredging will also be performed during the proposed expansion of Town Cut. Town Cut is to be expanded by 15m on the South side.

* A study is conducted at present to assess the optimal means for disposal of dredge spoils by BBSR; this study is based on the outlines described in the London Dumping Convention document, to which Britain is signatory.

* It has been suggested that dredge spoils be utilised for the required landfill, namely in Hamilton where present plans require 2.5-5.5 acres of landfill.

* Effects of dredging in Hamilton may be greater than those expected in St. George's, as there is a higher portion of silt in Hamilton harbour sediments than in those of St. George's.

* The main concern in St. George's is the physical destruction of Higg's Island for the expansion of Town Cut.

* Tributyl tin (TBT) is presently used as antifouling paint on boats larger than 25m, such as cruise ships. There is a worldwide movement to ban TBT.

* Detailed scientific data exists on TBT levels in Bermuda's inshore waters and indicate that large ships (both container ships and cruise ships) are a potential source of TBT to Bermuda's coastal waters.

* Little is known on the long term impact of the proposed compounds to be utilised as an alternative to TBT. This issue also concerns leaching from small boats, boatyards, marinas.

* There is no legislation regarding dockside cleaning of ships in Bermuda, nor any adequate regulations regarding the input of any contaminants into Bermuda waters. The only available act is the Water Resources Act, which does not provide any specific limits on contaminants entering the water column.

* The Department of Marine & Ports has the right to inspect ships to assess their compliance to international environmental laws. Approximately 15% of the ships coming into port are inspected.

* There is good existing legislation concerning oil spills in the inshore waters, as outlined in the Oil Spill Act. There also exists a contingency plan in Bermuda to prevent damage to the marine

and land environment following an oil spill; cruise ships also have their own contingency plans. There does not seem to be any control of oil spills occurring outside of Port in territorial waters.

* Permits are required for the operation of any plant aboard ships visiting the island.

* The Clean Air Act provides good standards in Bermuda; however, analysis of emissions has been performed on a sporadic basis, following complaints by residents and boat owners. Sulfur dioxide was the only noxious gas measured, and organic pollutants were not determined.

* The percentage of soot accumulation generated by cruise ships on residential roofs has not been assessed. The long term impact of accumulation in domestic water tanks is not known.

* There are at present guidelines but no regulations for drinking water quality in Bermuda, set by the Public Department of Health.

* There is a study conducted at present modeling the emission movements from cruise ships in all three ports, by scientists at BBSR. Present cruise ship specifications are utilised for the model.

* There are laws regarding noise pollution in the Summary of Offences Act; these are not enforced with respect to outside entertainment on cruise ships, under the pretense of lack of night activities and shows for cruise ship passengers, in port towns.

* A detailed document outlining the present issues relating to transport and infrastructure in Bermuda is available.

* Both the Department of Tourism and Transport admit that with the present day limit of 6000 passengers/day, there are periods where the public transport system experiences serious overloads, causing negative perceptions from both cruise ship visitors and land-based tourists. Cruise ships passengers tend to travel at the same time, creating sudden bursts of flow on the island.

* Present infrastructure, in terms of numbers of restroom, bus terminals, ferry services, etc. is not adequate for the accommodation of present limit of cruise ship passengers, namely in Hamilton and St. George's.

* The Consultant Firm hired by government to modify the existing cruise ship berths considers the flow of passengers from cruise ship to bus/ferry/taxi only.

* Detailed improvements of existing infrastructure are taken into consideration by the Consultant firm for Front Street, Hamilton.

* Little has been presented by the Consultant Firm at the present date regarding infrastructure improvements to St. George's. St. George's Corporation is attempting to move towards better facilities, but plans appear vague.

* St. George's is the most popular port for shore excursions booked on the ships on their day at sea en route to Bermuda. Dockyard is the least popular for shore excursions.

* As no single group is responsible for transportation decisions in Bermuda, it was advised to government that a Transportation Authority be established to develop and regulate an integrated on-island transportation system for visitors and residents.

* The cruise ship industry contributes to Bermuda's revenue by passenger expenditure when on land, service fees to Marine & Ports, docking fees to the Corporations, and passenger tax.

* Cruise ship passenger expenditure equates approximately ¼ of air passenger expenditure (excluding accommodation expenses for the latter).

* The cruise line industry pays no payroll tax, no duty on supplies, nor do they purchase any energy; the cruise lines make no social contributions to the island. To counteract this, a Permit Fee was created by a Review Committee.

* The Department of Tourism is at present considering various ways to increase tourism in Bermuda: super cruise ships, eco-tourism, up market land-based tourism and SCUBA destination. It is questionable as to whether all these forms of tourism are possible on a 21 square mile island. There appears to be no long term direction for tourism in Bermuda.

* Bermuda receives 2% of the worldwide cruise industry; yet Bermuda is perceived to be one of the most highly profitable routes for the cruise ship industry.

* The long term impact of the cruise ship industry on land-based tourism is questioned in many of the Caribbean islands, and a matter of concern in Bermuda. An environmental levy has been imposed by some of the Caribbean islands on the cruise ship industry.

* There is no existing knowledge of the carrying capacity of Bermuda as a whole, nor any apparent intent to obtain this information. Unlike other areas, Bermuda does not have the place to expand.