

VESSEL WASTE CONTROL PLAN
FOR THE U.S. VIRGIN ISLANDS

BY

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ABSTRACT

Waste streams, sewage, waste oil and trash for 400 boats were determined through a survey effort (including interviews) of vessels at eleven harbors or anchorages in the U.S. Virgin Islands (St. Thomas, St. Croix and St. John). Unit waste loads, waste discharges per boat for various size boats up to 100 feet were calculated as well as total discharges of sewage into anchorages. Other significant point and non-point pollution sources at the anchorages were identified and quantified where possible. Recommendations are provided which would reduce or minimize adverse impacts on coastal water quality.

Existing legislation, relevant to the control of boat waste discharges, was identified and assessed in terms of applicability and effectiveness to the Virgin Islands situation. Recommendations for changes or amendments to the laws have been provided.

Existing agencies dealing with vessel pollution water quality and resource management were identified and evaluated. Recommendations are provided to carry out the proposed changes in the management programs; and estimated manpower, budgetary and implementation time frames are provided, along with some strategic guidelines for future modifications of public policy.

FINAL REPORT
VESSEL WASTE CONTROL PLAN

I. INTRODUCTION.

Boating and related supporting services have become a major industry in the U.S. Virgin Islands over the past two decades. The impact of this activity sector on Virgin Islands coastal waters remains essentially undefined, and even the dimensions of the boating base figures are lacking in precision.

In a 1979 study of recreational boating in the Virgin Islands carried out by the Island Resources Foundation for the National Marine Fisheries Service, it was determined that there were (as of January 1, 1978) 1,789 DCCA registered boats in the Virgin Islands. By 1981, this figure had risen to 2,924 vessels.

However, the Virgin Islands boat registration figures do not include (a) documented vessels (itinerant or resident); (b) foreign registry vessels (itinerant or resident); and (c) visiting, undocumented U.S. vessels registered in a state or in Puerto Rico (itinerant or resident). Boats, by definition, are eminently mobile, and, as such, an ephemeral factor must be confronted in any attempt to carry out a survey of their activities.

Since the boating industry, in all its complexity, is nonetheless important to the Virgin Islands economy and to its unique insular status within the framework of the Lesser Antillean archipelago (which, almost uniformly is engaged with the same problem of development versus regulation of the boating industry and related supporting services), it is important to have available quantitative data on the dimensions of waste disposal practices by small boats utilizing Virgin Islands coastal waters, harbors, anchorages, marinas, etc.

Under the terms of reference as outlined in DCCA RFP #0013-82, as cited in the contract as addendum 2, the Island Resources Foundation (hereinafter referred to as IRF) as contractor was charged with a sequential set of tasks to assist the Government of the Virgin Islands with the

preparation of a Vessel Waste Control Plan. The required services to be provided by IRF as the contractor are outlined in detail in the RFP cited and are summarized as follows:

General Tasks: ● Evaluate current vessel waste practices in the Virgin Islands through literature search and surveys (phase 1);

● Design a management program ... (phases 2).

Specific Tasks (phase 1):

- Evaluate current vessel waste practices
 - literature review
 - survey of vessels
 - assessment of results with relation to other specified bay/harbor loading
 - report with matrix summary;
- Inventory and review of existing Virgin Islands legislation and management programs
 - analysis of agencies responsible
 - analysis of legislation for comprehensiveness
 - evaluation of the effectiveness of implementation
 - identification of deficiencies
 - report.

Specific Tasks (phase 2):

- Draft legislation;
- Design management program;
- Provide cost estimates for proposed management plan and implementation time frame.

II. THE SURVEY EFFORT.

A. Sample Selection.

Ten percent of all boats, less than 100 feet or under 100 tons, were to be surveyed in the Vessel Waste Disposal Survey. In order to establish the total number of boats in the territory, several sources were utilized.

1. Virgin Islands boating registration records which are maintained and updated annually by the Environmental Enforcement Bureau of the Department of Conservation and Cultural Affairs (DCCA). That source indicated a total of 2,924 boats in the Virgin Islands -- 2,210 on St. Thomas and St. John and 714 on St. Croix for 1981. This registration is limited to resident boats with motor propulsion which are not Coast Guard documented. Visiting boats with other state registration have a 60 day period in which to apply for a Virgin Islands registration, but some appear to ignore this rule, especially if they do not plan an extended stay and do not enter the recreational charter business. The actual number of boats in this category is, therefore, unknown.
2. An aerial boat count taken of all anchorages by DCCA personnel on July 15, 1981, and other information from a report entitled Environmental Information Relevant to the Installation of Boat Moorings in the Coastal Waters of the U.S. Virgin Islands, 1981.
3. Perusal of Bureau of Customs records on St. Thomas for the number of vessels and their length of stay. This applies to all foreign flag and United States commercial vessels.
4. A report prepared for the Virgin Islands Department of Commerce entitled Survey of Charter Boating and Related Businesses in the Virgin Islands Relative to Their Contribution to our Tourism Related Economy (by Clyde Carder, July 14, 1980).
5. Direct boat counts in selected anchorages to verify and update the above information.

On the basis of the information reviewed from the sources indicated above, the total boating population for the purposes of this study is estimated at 4,000. The actual number obviously varies from day to day as well as seasonally.

B. Areas of Study and Sampling Distribution.

The anchorages* to be included in this study were selected by the Department of Conservation and Cultural Affairs, Division of Natural Resources Management (DCCA/DNRM) and are as follows with the actual number of interviews shown:

<u>Anchorage</u>	<u>Number of Interviews</u>
ST. CROIX --	
Christiansted	44
Tague Bay	20
ST. THOMAS --	
Long Bay	92
Paquereau	8
Frenchtown	30
Honeymoon (Water Island)	5
Elephant (Water Island)	7
Lagoon	76
Cowpet	7
Red Hook/Vessup	64
ST. JOHN --	
Cruz Bay	47
	<u>400</u>

C. The Survey.

The interviews of boat owners/operators for each anchorage were distributed between docked and moored boats on the basis of the number of boats indicated by the aerial and ground counts as reported by DCCA. Although only about ten percent of the total number of resident Virgin Islands boats were interviewed, the actual percentage surveyed at the specified anchorages was greater than twenty-five percent. The specified anchorages contained slightly less than 1,400 boats. Owners of smaller trailerredboatsandboats in

*The word anchorage used throughout this report, unless otherwise specified, denotes a protected coastal embayment with boats at anchor, on fixed moorings, or at docks, piers, or slips.

dry-storage were not interviewed, although these vessels are included in the total estimate of 4,000.

On the basis of the DCCA aerial counts and boating registration records, it was estimated that of the total small boat fleet, 25 percent is located on St. Croix, 11 percent on St. John and 64 percent on St. Thomas. The initial project planning called for the interviews to be distributed proportionally among the islands. However, due to problems encountered with the interview effort on St. Croix (resulting in approximately 60 unuseable interviews*), only 64 interviews were available, representing 16 percent of the St. Croix fleet. Although additional efforts could have been expended to obtain the full 25 percent, it became apparent during the work that such was not necessary. First, the waste generation of individual vessels is not dependent on location, and since the total number of live-aboard boats was determined independently from the interviews, the total waste loading at the two St. Croix anchorages would still be determined. Secondly, St. Croix has a large percentage of trailered boats which, for the purposes of this study, were not relevant but which had been included in the total estimate of boats on St. Croix. The interviews not completed on St. Croix were, therefore, taken on St. Thomas.

Each interview was recorded on a form, a copy of which is provided in the appendix to this report. The questionnaire distinguished, among other items, whether persons living aboard also worked ashore or attended school ashore for such information would have an effect on the volume of waste discharged into coastal waters from the boat. Specific information was obtained on sewage discharges and trash and waste oil disposal. Although other pollutants certainly result from boating activity, it was felt that such information (e.g., toxic paints, solvents and out-board discharges, occasional and accidental fuel spills, among others) could not be sufficiently documented to be of significant value within the scope of this survey effort.

The number of boats counted at each anchorage, including liveaboards and sampling numbers, are summarized in Table 1.

*The interviews taken failed a verification test strategy applied by IRF project staff in a post-interview check on reliability.

ANCHORAGE	TOTAL BOATS*			BOATS INTERVIEWED					
	#1	#2	#3	#4	#5	#6	Discharging Sewage		
	# In Anchorage	# Live Aboards	% Live Aboards	At Anchorage	Live Aboards	% Live Aboards	#7 #	#8 % of #4	#9 % of #5
Christiansted	156	36	23%	44	21	48%	14	32%	67%
Tague Bay	91	12	13%	20	8	40%	6	30%	75%
Long Bay	296	203	69%	92	58	63%	44	48%	76%
Pacquereau	35	(14)**	(40%)	8	3	38%	3	38%	100%
Frenchtown	55	14	25%	30	10	33%	7	23%	70%
Honeymoon	13	(5)	(38%)	5	5	100%	4	80%	80%
Elephant	58	23	40%	7	6	86%	6	86%	100%
Lagoon	311	86	28%	76	51	67%	39	51%	76%
Cowpet***	59	--	--	7	1	14%	0	0	0
Red Hook/Vessup	196	78	40%	64	43	67%	25	39%	58%
Cruz Bay	75	32	43%	47	24	51%	15	32%	63%
TOTAL OR AVERAGE	1,345	503	38%	400	230	58%	163	41%	71%

TABLE 1. Anchorage Sewage Discharge Characteristics.

*Counts on total boats were taken during January, February and March, 1983, except for Pacquereau and Cowpet, where DCCA aerial counts were used.

**Numbers in () are estimates.

***No estimate made; see discussion on Cowpet in text.

D. Interview Distribution by Boat Size.

The specific break-down of interview data by boat size is found in Table 2 below. The highest percentage of interviewed boats (49%) is for those vessels between 26 to 40 feet in length, with 34 percent recorded for those 40 feet to 65 feet. A separation of live-aboards from the interviewed group by boat length showed the same general trend, with the 26 to 40 foot boats comprising 48 percent of the group.

TABLE 2.						
Boat Size Distribution for Total Interviewed Group and for Live-Aboard Group.						
	BOAT LENGTH (ft.)					Total
	16	26	40	65	65+	
# Total Interviews	11	44	192	133	9	389
% of Total	3%	12%	49%	34%	2%	100%
# Live-Aboard Interviews	1	13	107	96	7	224
% of Live-Aboard Interviews	<1%	6%	48%	43%	3%	100%

III. MARINE HEADS AND HEALTH ASPECTS.

Marine heads or toilets can be grouped into three main categories:

1. Direct discharge of sewage into receiving water;
2. Some form of sewage treatment or conditioning before discharge;
3. Discharge into on-board holding tank for later disposal into water or land based sewage system.

Some other forms are also in use but in very limited numbers.

The direct discharge head flushes the waste directly into the water without any form of treatment. The discharge piping is usually $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter with some form of one way valve and a vented loop higher than the water line, preventing the back flow of water into the boat. While the waste undergoes some break-down and size reduction by its passage through the piping/valve/loop system, floatable portions and material may still be visibly present after discharge from the boat.

The second category is sub-divided into various forms of mechanical, biological and chemical conditioning of the waste material. The Marine Sanitation Device (MSD) Regulations enforceable by the U.S. Coast Guard have set effluent limits for three types of systems: Type I and II which treat sewage to specified limits and Type III which is the holding tank option.

Type I - requires that the effluent contains no floating solids and has a fecal coliform bacterial count of not more than 1,000 per 100 ml of effluent.

Type II - requires a maximum limit of 150 mg/l of suspended solids and not more than 200 fecal coliform per 100 ml.

The Type I effluent requirement is generally achieved through maceration, a means of mechanical cutting or chopping resulting in a liquid slurry which is then discharged. Since this is customarily accomplished by a mechanical apparatus driven by an electric motor,

it is subject to failure and has a significant power demand which, for some sailboats with minimal electrical systems, can present a serious problem.

The Type I system can be installed on boats up to 65 feet in length. Larger boats must have either Type II or Type III systems, according to MSD Regulations.

The effluent requirements of Type II are achieved either through a biological/chemical or physical/chemical process. Each manufacturer has its own unique system and obtains Coast Guard approval if the performance standards set forth above are met. Chlorine is the usual disinfecting agent although formaldehyde is also occasionally used. Each proprietary system has its own drawbacks and advantages; however, invariably all of them consume space which, on smaller sailboats, is at a premium. As noted above, however, boats 65 feet or smaller are permitted to have Type I systems.

Type III, the holding tank, is the only system capable of achieving total separation of sewage from receiving waters, assuming the accumulated sewage is eventually pumped into a land based sewage system. Alternatively, pumping out in the open sea well offshore also has no significant or measurable impact upon the environment.

The two principal concerns arising from sewage discharges (from any source) into receiving coastal waters are the effects on the natural ecosystem and the possible negative impact on human health. The effects on the natural ecosystems have been severe in some coastal embayments and harbors in the Virgin Islands and are discussed in some detail in the next section of this report.

But as far as health impacts are concerned, no cases have been reported where sewage in Virgin Islands coastal water has been identified as the transmission vehicle (personal communication, Dr. John Lewis, director, Community Health Service). In general, for this to occur, sewage from a disease carrier must be discharged into water which is then ingested by a non-infected person who may then develop the disease. While the die-off of sewage bacteria in seawater is much more rapid than in fresh water, the survival of viruses from days to weeks in seawater has been noted (33, 34).

IV. NUTRIENTS.

The adverse effects on marine water quality due to nutrient enrichment from sewage and other sources have been recognized for some time and have occurred extensively at some coastal embayments in the Virgin Islands.

The principal effect of nutrient enrichment (over fertilization) of receiving waters is the excessive growth of specific organisms, changing the normal or natural distribution pattern of aquatic organisms and affecting their predator-prey relationship. While excessive nutrient input into semi-enclosed water bodies is generally responsible for nuisance growths, changes in temperature, salinity or turbidity have also been found to result in abnormal growth of certain organisms (35).

It is generally known that the essential elements for plant growth include nitrogen, phosphorus, potassium, magnesium, calcium, manganese, iron, silicon (for diatoms), sulfates, oxygen and carbon plus various trace elements. Phosphorus and nitrogen have received significant attention as they are present in sewage in significant quantities and have been determined to cause abundant vegetative growth (i.e., algae) if other habitat conditions are favorable (35). Excessive algae growth, in turn, sets up a chain of events which affects the aquatic ecosystem. Light transmission, necessary for bottom plant growth, is reduced; dead algae increase the oxygen demand on the water through their decomposition process; diurnal fluctuations in dissolved oxygen and Ph result which can be detrimental to other organisms, to list only a few of the better known effects (36).

Two studies in the recent past have addressed themselves in part to the question of nutrient inputs into Virgin Islands coastal embayments. Nichols (1979) examined the runoff effects of a major storm event on the St. Thomas mangrove lagoon (28), while Purcell (1980) observed the effect of rainfall from natural watersheds on two bays on St. John (37).

The general conclusion of the report on storm flooding into the mangrove lagoon was "that flooding triggered 'worst case' conditions for water quality with potential ecological consequences extending for years." While this study observed only one major event, the lower volume but continuous sewage effluent discharges into the lagoon, principally from the Nadir plant, and the base flow of Turpentine Run, into which several sewage plants discharge, are probably much more significant due to their cumulative effect. The above cited report also identified those sources as major contributors of nutrients into the lagoon.

The work of Purcell (1980) documents the effects of runoff on bays from undeveloped watersheds, thus providing for some baseline data. The general conclusion of that work is that while storm water runoff carries appreciable concentrations of sediments and nutrients, the unaltered natural states of the low lying discharge points near the sea resulted in a buffering and mitigating action on the storm discharge. Vegetation, mangrove areas, mud flats, and beach berms slow storm runoff and reduce its sediment and nutrient load (37).

The effect of runoff from developed or developing watersheds on St. Thomas' near shore embayments has been further complicated at Vessup Bay, the Mangrove Lagoon, Cowpet Bay and Water Bay by the appearance of algae blooms (genus *Peridium*). The simultaneous appearance of the blooms occurred after very heavy rains in September and November, 1979. Nutrients from land runoff were suspected as the cause of the blooms (10). The specific sources of nutrients were not identified; however, earth moving activities have been observed in the related watersheds (personal communication, Pedrito Francois, Assistant Commissioner, Department of Public Works).

The relative magnitude of soil erosion to the contribution of nutrient enrichment of coastal waters in the Virgin Islands has received little attention, although its combination with nutrients may be more significant than generally realized. McElroy (1976) developed nutrient/soil erosion relationships for use in the continental United States, indicating that the problem is significant enough to warrant identification and quantification (30). On the basis that rainfall is generally of short duration but high intensity and given the generally steep land slopes, particularly on the islands of St. Thomas and St. John where over 70 percent of the land is in excess of 20 percent gradient, it is readily apparent that the erosion potential for disrupted earth in the Virgin Islands is great.

This can generally be observed on the numerous steep earthen (non-paved) roads which repeatedly must be graded due to massive gully erosion making such roads impassable to vehicles after heavy rains. Usually such roads also lack the simplest form of storm drainage control.

The adverse impact on near shore waters (and also on man-made drainage structures through clogging with sediment and resultant flooding) of such land development practices is not only limited to excessive nutrient input but includes also sediment damage and an increase in the peak flood flows. In short, the gross failure of the soil erosion control program in the Virgin Islands has far reaching consequences for both man's immediate environment and natural ecosystems through flooding damage and sediment transport and deposition.

V. WASTE STREAMS AND LOADING FACTORS.

A. Vessel Waste Generation.

For the group of interviewed boats, a quantitative assessment was made of three basic types of vessel waste: sewage, used lubricating oil and trash. A summary of the data obtained is shown in Table 3.

There are, of course, other types of discharge or spillage from most vessels, in particular, the gradual release of toxic compounds from bottom paints and the spillage or discharge of fuel oil, bilge water and detergents used in cleaning, plus paint, varnish, epoxies, polyester resins and other chemicals utilized in boat maintenance. These lesser waste streams, however, could not be readily quantified through the interview data gathering method employed for this study. Therefore, primary emphasis was placed on sewage, waste oil, and trash.

While the latter two lend themselves to volumetric assessments, the first -- vessel sewage -- does not since it is discharged in and with varying amounts of water resulting in varying concentrations. We have, as a consequence of this, resorted to a different kind of assessment or quantitative measure, utilizing the known BOD of human sewage per person per day. Since some readers may be unfamiliar with BOD, a brief explanation is in order.

BOD is the acronym for biological oxygen demand, expressed in milligrams (mg) per liter (l) which decomposing waste places on the receiving water over a period of five days at 20° C. More specifically, it is the quantity of oxygen consumed by bacteria and other organisms utilizing the waste as their energy and nutrient source. As such, BOD is a measure of the instability of the waste. BOD was selected over other pollution indicators as it is a commonly used measure of pollution severity, it can easily be determined by simple laboratory procedures, and it has a well established constant of 0.176 lbs./day/person -- the latter being the average quantity of oxygen required for the decomposition of human waste produced in one day. This conversion constant was necessary to convert the waste from the number of persons on live-aboard boats to a site specific BOD load which could be compared to other BOD loads from other sources, such as sewage treatment plant discharges in the same anchorage.

ANCHORAGE	# of Boats Interviewed	# Discharging Sewage	BOD Load lb./yr.	Waste Oil gal./mo.	Trash lb. / week
X'sted.	44	14	550	12	780
Tague Bay	20	6	190	7	300
Long Bay	92	44	1,880	59	2,680
Pacquereau	8	3	70	8	160
Frenchtown	30	7	240	7	470
Honeymoon	5	4	230	2	80
Elephant	7	6	330	2.5	70
Benner	68	32	1,580	16	1,440
False Ent.	8	7	390	0.5	160
Cowpet	7	0	0	2	60
Vessup/ Red Hook	64	25	1,350	12	1,360
Cruz Bay	47	15	600	16	500
TOTAL	400	163	7,410	144	8,060

TABLE 3. Waste Generation From Interviewed Boat Group
By Anchorage.

The BOD determinations cited in Tables 3 and 5 were based on the interviewees' responses regarding the number of persons living aboard. This, however, was qualified as to whether the heads on board were used and how many of the persons living aboard also worked ashore or otherwise were generally away from the vessel during the day. If the response was that heads were not used, then no BOD computation was made in the data analysis for that vessel. For boats with persons living aboard but generally ashore during the day, only 50 percent of the daily per capita BOD load (0.176 lbs.) was used.

The data gathering effort regarding vessel wastes had two principal, independent components:

1. The direct interview of 400 boat owners or crew, and
2. The counting of the total number of boats at each site with an estimate of the number of live-aboard boats.

The estimate of live-aboards at each anchorage was deemed especially important if the total BOD or sewage load was to be determined. It could not be determined through the direct interviews as they were not necessarily representative of all categories of boats in any given anchorage. The estimate was based on the visual appearance of a boat while travelling through an anchorage. Evidence of habitation usually included some combination of drying laundry, pets, toys, children, plants, heavy bottom growth, awnings in place, cabin lights at night, etc.

Obviously, in the live-aboard count by anchorage, some boats may have been included which were not live-aboards but appeared so perhaps due to ongoing maintenance work and/or temporary occupancy. Consequently, it is possible that the full-time live-aboard boat population figures for anchorages may be slightly over estimated. However, on the basis of this counting method, 19 percent of the St. Croix boats were found to be live-aboards, 42 percent on St. Thomas, and 35 percent on St. John, with the average for all islands of 38 percent, noting, however, that the percentage at each anchorage varies both spatially and temporally.

The direct interview effort did not result in the same percentage of live aboards as the above total counts. This was to be expected as the probability of finding a person on board who lives on the boat is much greater

than one who uses a boat occasionally. Table 1 (page 6) provides the percentage of live-aboards from the interview group.

The information of significance is the number or fraction of vessels which discharge sewage. On the basis of the interviews two trends seem apparent. One, not all live-aboard boats discharge sewage and, two, significantly fewer boats at docks (or marinas) discharge sewage as compared to moored boats. Note, however, that this applies to the total number of boats discharging sewage, not the sewage contribution of individual boats.

Of the total interview group, 230 were found to be live-aboards, of which 163 (or 71 percent) reported to be discharging sewage while at the anchorage (see Table 1). The separation of the data by island (shown in Table 4) was consistent with the total average: St. Croix, 72 percent; St. Thomas, 72 percent; and St. John, 63 percent.

The second trend, the difference in sewage discharges based on a mooring or dock location of the boat is evident mainly for data from St. Thomas (see also Table 4). The sample of live-aboards on St. Croix at dockside was very small (three out of 14 interviewed), and the three all reported to discharging sewage. On St. John there are no commercial marinas. On St. Thomas, 85 percent of live-aboards at moorings/anchorages reported discharging sewage, while at dockside it was only 52 percent. Clearly, the availability of shore-based toilet facilities and policies against sewage discharge at some marinas seemed to be responsible for this difference.

A reasonable assumption was made that the larger boats, with more persons on board, would produce larger waste streams. Table 5 summarizes the waste streams from the interviewed boat group categorized by boat size. Note that BOD load (column 4) and the BOD lb./per boat as well as the population equivalent are based on data from boats with sewage discharges. The unit boat BOD load, i.e., lb. BOD/per boat indicates an increase with boat size (the 16 foot boat size should probably be disregarded as it only represents one interview). Note also that the indicated boat size represents a size range, i.e., the 40 foot "size" indicates boats ranging in size from 26 feet, one inch to 40 feet. The unit boat BOD load is the mean value for the indicated boat size. The value of 45 lb. BOD/boat/year is the mean for all boats.

With this unit load value and the approximate 70 percent discharge factor, it should be possible to obtain an

	# Liveaboards	# Discharging Sewage	% Discharging Sewage	Total Interviewed	
				Moored	Docked
<u>St. Croix</u> Moored	26	17	65%	50	
Docked	3	3	100%		14
SUB-TOTAL	29	20	69%		
<u>St. Thomas</u> Moored	111	94	85%	153	
Docked	66	34	52%		136
SUB-TOTAL	177	128	72%		
<u>St. John</u> Moored	24	15	63%	44	
Docked	0	0	0		3
SUB-TOTAL	24	15	63%		
<i>TOTAL</i>	230	163	71%	247	153

TABLE 4. Live Aboards Which Discharge Sewage.

# 1 BOAT SIZE (Up To)	# 2 Number Interviewed	SEWAGE				WASTE OIL			TRASH	
		# 3 # Discharging Sewage	# 4 BOD (from #3) lb./year	# 5 * lb. BOD per boat/year	# 6 ** Population Equivalent	# 7 Gal./Month	# 8 Gal./Boat	# 9 % of Total	#10 lbs./week	#11 Unit / lb. / week / boat
16'	11	1	64		1	0.7	0.06	< 1	40	4
26'	45	13	360	28	7	7	0.16	4	345	8
40'	198	83	3,841	46	60	59	0.30	37	3,173	16
65'	137	61	2,892	47	45	79	0.60	49	3,957	29
65' +	9	5	294	50	5	14	1.50	9	595	66
Total	400	163	7,406	45	118	160	0.40		8,110	20

* Column #5 is based on number of boats discharging sewage.

** BOD from column #4 divided by 0.176 lb. BOD/person/day divided by 365 days.

TABLE 5. Vessel Waste Generation of Interviewed Boats by Boat Size.

approximate value of sewage loadings from boats in other Virgin Islands anchorages not covered in this survey. A visual count of live-aboard boats would need to be made at an anchorage and, if possible, a count by boat size to which the unit load factors from Table 5 are applied (after adjustment to account for live-aboards not discharging sewage). However, specific circumstances such as enforced prohibition against discharges by specific marinas need to be taken into account. If the size distinction cannot be made in the field, but the majority of boats are larger than 26 feet, then the overall unit load factor could be applied, i.e., 45 lb. BOD/boat/year.

A unit loading analysis had been made for each anchorage on the basis of whether a boat was docked or moored; however, no consistent pattern resulted which indicated that the boat size and, consequently, the number of persons which can be accommodated is the controlling factor in unit sewage loads.

The population equivalent in Table 5 is a representation of the number of persons who would produce the equivalent sewage load. This is not, however, the number of persons found residing on boats in the interview group, which would be greater than the total of 160 due to the BOD reduction related to persons spending the day ashore.

The waste oil produced by boat engines is not directly related to living aboard a boat except in cases where engines are used to drive electric generators. Almost all interviewees reported on the quantity of waste oil, and on a unit production basis it appears to be dependent largely on vessel size and type of vessel usage, with less than 0.1 gal./month for 16 foot boats and up to 1.5 gal./month for 65 foot or larger boats, the average being 0.4 gal./month. In the smaller size ranges, one would find proportionally more outboard engines which do not produce crank case waste oil as they are of the two stroke design where the lubricant is added to the fuel.

Waste oil has two significant impacts. It is a serious pollutant if not properly contained and disposed of, but it also has a major benefit in that it can be burned as fuel in oil fired power plants. Most marinas provide for waste oil collection, and some of it is transported to the Water and Power Authority electric plant on St. Thomas. However, other less benign forms of disposal are also practiced on St. John and St. Croix, including the use of public sanitary land fills and private dumps.

Trash pollution follows the same pattern as waste oil, with four lb./week/boat for 16 footers and up to 66 lb./week/boat for 65 foot boats, with a mean of 20 pounds per week per boat.

All Virgin Islands marinas, as business establishments, are required by law to provide trash collection services. The larger marinas all do so, but some smaller, more informal marinas do not. However, many boats are not moored at marinas and either use the nearest marina trash facilities or public roadside collection bins. In some locations, like Cruz Bay and Christiansted, the lack of convenient collection bins has presented a problem. In the case of Christiansted, trash is often deposited surreptitiously at night on the waterfront bulkhead. Placement of additional public trash collection bins in appropriate locations would probably help to resolve this problem.

A continuing coastal trash and litter problem results from floatable trash from unknown ships and vessels finding its way to the bays and shores of the islands. Plastic bags have been reported to clog cooling water intakes on boats causing serious engine damage, and many windward beaches and mangrove systems experience infusions of floatable wind and wave driven trash from unknown sources. It is quite unlikely that these floatables are generated by locally owned and based yachts, charter boats, and recreational vessels due to the peer pressure implicit within the boating community at any given anchorage. Visiting, in-transit boats are the probable source.

B. Type Heads on Interviewed Boats.

One of the survey interview questions elicited information on the types of heads on boats. All vessels, including foreign, in United States waters are required to conform to the Marine Sanitation Device Regulations, which require at least Type I devices on boats up to 65 feet and Type II and III devices for larger vessels.

On the basis of the responses to the interviews, Table 6 is provided which summarizes the types of heads by boat length. When viewing the total interview group, 78 percent met the MSD Regulations, noting that vessels not equipped with heads are exempted. This latter category represented a significant fraction, nearly 20 percent. Direct discharge, i.e., not meeting the federal requirements, accounted for 24 percent.

Boat Size (up to)	Number Interviewed	TYPE OF HEAD			% Interviewed (with head)	Direct Discharge	% Interviewed (direct discharge)	No Head	% Interviewed (no head)	Other
		I	II	III						
16'	11	0	0	0	0	0	0	11	100%	0
26'	45	0	1	5	14%	7	16%	30	66%	2
40'	198	12	17	84	57%	52	26%	32	17%	1
65'	137	11	14	77	74%	33	24%	2	2%	0
100'	9	0	1	4	55%	3	33%	1	11%	0
Total	400	23	33	170	57%	95	24%	76	19%	3

TABLE 6. Type of Head by Boat Size.

When the data is viewed by boat size, the size range from 16 to 26 feet represented the highest percentage (166) with no head on board, while the highest compliance percentage was found in the 40 to 65 foot range, i.e., equipped with approved MSD's. This finding is consistent with the general observation that many of the charter fleet boats are of recent manufacture, and any new vessel manufactured after January 30, 1977, must have been built with an approved MSD. In retrospect, it would have been useful to obtain the date of construction of the boats surveyed.

The above information should be considered within the context of the data acquisition method employed. It was based on the response of the person interviewed on board, and the degree of familiarization of that person with the boat varied. It was beyond the scope of the survey effort to actually inspect the equipment. Further, the above data does not reflect the observation of the U.S. Coast Guard spokesperson in St. Thomas who reported that 60 to 75 percent of inspected vessels were found in violation of the MSD Regulations. To what degree the above observation accounts for this discrepancy is not apparent. It should also be noted that in some cases where a "no head" response was provided, it was qualified as meaning that the equipment was out of service either temporarily or permanently, which technically may have been a violation of the MSD Regulations.

C. Waste Loading Projection at Anchorages.

On the basis of the information obtained from the interview group and the independent count of total and live-aboard boats at the anchorage sites, it was possible to extrapolate the wasteloading information to the entire anchorage, as reported in Table 7.

For all three waste streams -- sewage, waste oil and trash -- the per boat unit rates are proportioned to boat size (refer to Table 5, page 17); however, when considering the total waste load from a given number of boats, only sewage loading is directly proportional to the number of live-aboards. Except for the earlier analysis of unit or per boat waste oil and trash loads (Table 5), no further analysis was attempted. It was previously noted that data acquisition was not based on objective measurement but rather the recollection and judgement of the person interviewed. Further, a number of other factors such as extent of boat use (i.e., frequency and extent to which vessel left the anchorage) and the type of use (where it was generally observed that the commercial charter boats generate larger volumes of trash) influenced the quantities of waste oil and trash produced.

TABLE 7. Waste Loading Projection.

Moored	Docked
--------	--------

Anchorage	NUMBER OF BOATS		% LIVEABOARDS	BOD LOAD Lb./Yr.	POPULATION EQUIVALENT (see text)	WASTE OIL Gal./Mo.	TRASH Lb./Week
	TOTAL	LIVEABOARDS					
CHRISTIANSTED	70 86	20 16	29% 19%	600 820	23	40	2,770
TAGUE BAY	50 41	12 0	24% 0	280 0	4	30	1,350
LONG BAY	155 141	145 58	94% 41%	5,360 1,530	93	190	8,620
PACQUEREAU	35 0	(14) 0	(40%) 0	340 0	5	35	690
FRENCHTOWN	21 34	8 6	38% 19%	210 80	4	10	860
HONEYMOON	13 0	(5) 0	(38%) 0	280 0	4	6	220
ELEPHANT	58 0	23 0	40% 0	1,260 0	20	20	580
LAGOON/BENNER	74 218	45 24	61% 16%	2,470 610	47	65	2,090
LAGOON/FALSE ENTR.	19 0	17 0	89% 0	820 0	13	1	480
COWPET	58 1	1 0	2% 0	0 0	-0-	15	480
VESSUP/RED HOOK	76 120	39 39	51% 33%	1,380 960	36	40	4,110
CRUZ BAY	47 28	32 0	68% 0	810 0	13	20	790
TOTAL	676 669	361 143	53% 21%	13,810 4,000	262	472	23,040 = 11.5 tons

Numbers in () are estimates

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The projected waste stream values, with the limitations noted above, provide information for management purposes. Both waste oil and trash quantities allow for at least some planning for collection and disposal efforts, whether it be via commercial marinas or public facilities. They further can be viewed as resources. If one assumes that the projected waste oil volume of 472 gal./month is 50 percent of the total Virgin Islands fleet, then approximately 326 barrels of waste oil are produced which can be utilized as low cost fuel in electric power plants, assuming an efficient, cost effective collection system of the "free" oil is maintained.

Trash disposal is presently a significant problem on St. Thomas and St. John. However, a resource recovery project (water distillation from trash incineration) is in the planning stage for both St. Croix and St. Thomas which would make all burnable trash a resource asset. The trash disposal situation on St. John, however, has no planned resolution and will continue to be a serious problem until the Department of Public Works properly maintains and operates the incinerator and its associated land fill/dump.

The total garbage volume generated on St. Thomas in 1980 was 44,000 tons (personnel communication, Pedrito Francois, Assistant Commissioner, Department of Public Works). The projected trash of 23,040 lb./week or 11.5 tons/week from 1,345 boats is approximately one-half of the total produced by the entire Virgin Islands boating fleet of 4,000 boats. Considering that approximately 64 percent of the fleet is located in St. Thomas, then the total St. Thomas fleet generates about 765 tons per year or 1.7 percent of the total St. Thomas trash production. One note should be made here: this figure represents only the trash generated on board the boats and does not take into account that fraction produced while persons from boats are on land nor other boat related trash generation (for example, vessels undergoing haul-out or repairs or abandoned, derelict and wrecked vessels).

The sewage or BOD load must be viewed in an entirely different context. While the projected figures could be useful for future planning of boat sewage pump-out facilities, the waste stream is presently discharged into the anchorage receiving waters. Sewage (domestic) is essentially an energy and nutrient source for aquatic organisms. However, if the receiving water is over-fertilized, serious consequences to the existing ecosystem occur as is evident at a number of poorly flushed bays in the Virgin Islands.

The primary parameters to consider are quantity of sewage (BOD or nutrient loading from all sources), the volume of the receiving water and the water exchange rate, i.e., flushing action of the bay. Water depth also becomes critical if propeller wash in shallower areas results in an increase in turbidity, thereby lowering light (energy) transfer to the water column.

The above are only some of the principal parameters as aquatic bio-chemistry is rather complex with some of the energy and nutrient pathways poorly understood. Thus, to make general observations at this point, based on the relative value of BOD produced at an anchorage, would be misleading. A subsequent segment of this report, entitled "Description of Bays, Impacts and Management Recommendations", provides a more comprehensive assessment of the major parameters affecting water quality at particular anchorage locations.

VI. DESCRIPTION OF BAYS, IMPACTS AND MANAGEMENT RECOMMENDATIONS.

The management recommendations resulting from the information obtained during this investigation are presented in two parts: (1) a general set of recommendations which apply to the entire Virgin Islands; and (2) a set of site specific recommendations for each of the anchorages. The latter was deemed appropriate due to the varied and unique features at some of the study sites selected by DCCA.

The harbors, bays, lagoons and other coastal water areas of the Virgin Islands are affected by various types and rates of pollutant discharge. One group of pollutants originates from boats which utilize coastal waters and consists largely of sewage, trash, petroleum based waste products, and the residue from routine boat maintenance activities.

The discharge of these materials in any given bay or harbor is variable depending on such factors as vessel type, size, use, and number; the size, shape, desirability, and concentrating effect of a given harbor or anchorage; and the proximity of land-based marina facilities and their operational policies, among other factors.

Some pollution management and abatement strategies exist with varying degrees of effectiveness at different locations. For instance:

- * Most larger marinas maintain waste oil and trash collection stations at their own expense. Some charge fees to users, while others do not. Some smaller marinas do neither.
- * Some anchorage/mooring areas have accessible public toilet facilities and/or trash receptacles on shore, while other areas do not.
- * Only a few marinas strictly enforce prohibitions against sewage discharges by docked vessels, but even fewer have vessel holding tank pump-out facilities (which are seldom used).

The role of physical forces and factors, such as the shape, depth, orientation, and flushing action of a given bay, is significant in determining the pollutant discharge rates that a particular bay can absorb. See Figure 1. Shallower bays and harbors with low flushing rates can only absorb low pollution loadings. This flushing capability (or

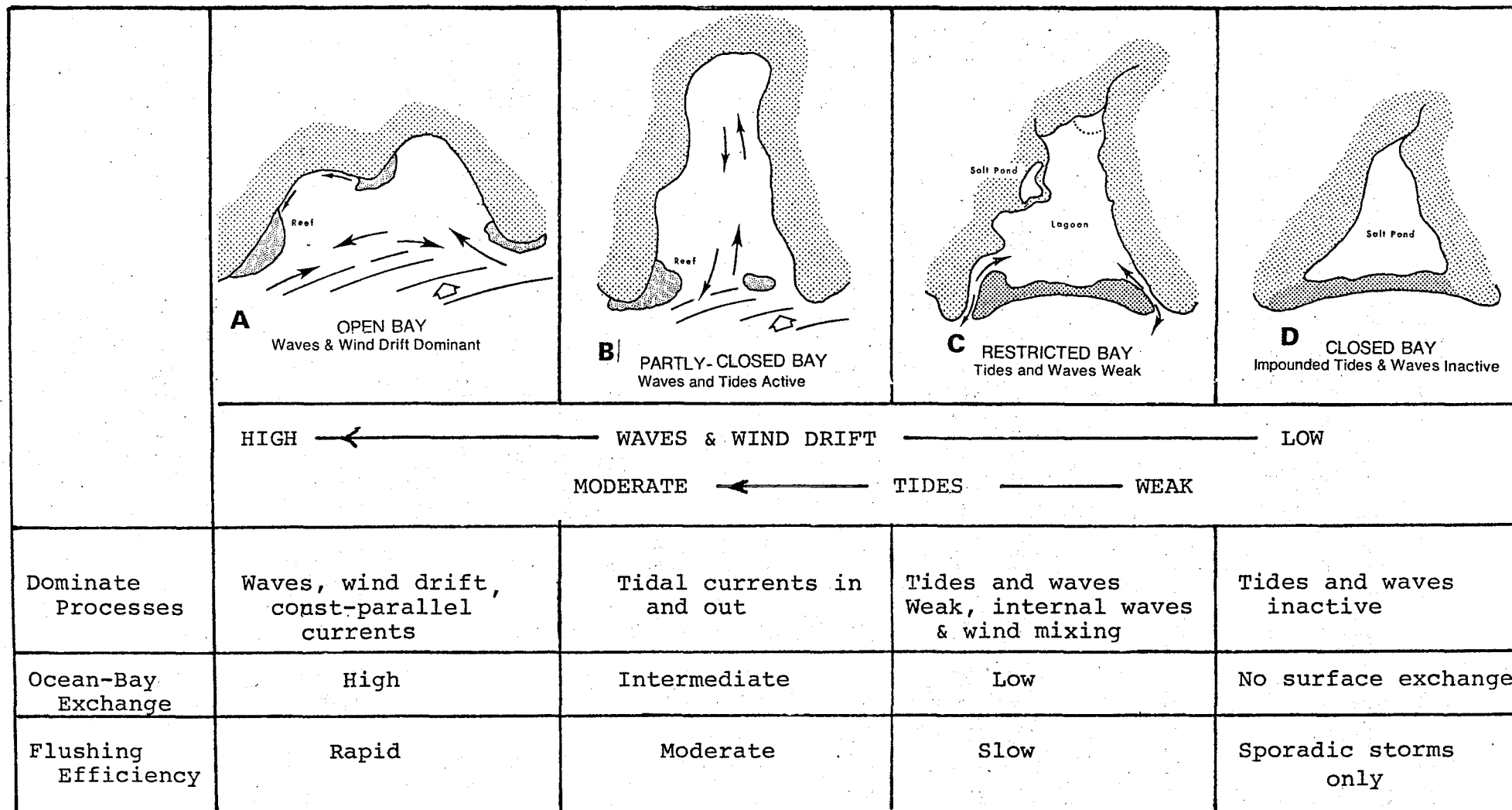


Figure 1. Different types of Virgin Island bays in a sequence organized according to closure, dominate processes and flushing efficiency.

SOURCE: *Virgin Island Bays: Modeling of Water Quality and Pollution Susceptibility* (Island Resources Foundation, April 1979). Prepared under contract to V.I. Government, Department of Conservation and Cultural Affairs.

dilution) approach is, of course, only valid within the limiting assumption that the more open coastal waters provide a high enough dilution rate (generally in excess of 150:1) so that pollutants have little or no measurable impact on coastal water quality and the associated coral reef and sea grass ecosystems.

This assumption is, however, not always valid for all pollutants -- for example, as in the case of the dredging on St. Croix' south shore which, in the 1960's at the Hess-Harvey/Martin Marietta industrial complex, resulted in excessive and prolonged turbidity conditions and had a serious adverse impact on the southwestern reefs and coastal fishing resources for many years. Therefore, the open ocean/coastal dilution concept may be used, while keeping its limitations in mind.

As will be discussed in detail under each site specific anchorage section below, a number of pollutant sources impinge upon most of the study areas and affect the water quality and ecosystem of each bay or harbor. Table 8 summarizes those main factors. Some sources such as live-aboard boats and sewage outfalls can be reasonably well quantified, while others -- such as storm runoff, shoreline sewage effluent disposal (septic tanks), irrigation, and dump leachates -- remain to be assessed. Some of the pollution sources are in proximity to the anchorage; while others, like the discharge of treatment plants into the Turpentine Run watercourse, are located several miles inland.

A. General Management Recommendations.

1. MARINE SANITATION DEVICES.

Based on the group of interviewed boats it was found that approximately 24 percent were not equipped with an approved Marine Sanitation Device, while another 19 percent did not have any marine head or had one which was not functioning.

The coastline of islands contains numerous sheltered bays extensively utilized by boats and where frequently popular water recreation activity centers are also located. The possibility of floatable, untreated sewage matter and related infecting agents (bacteria and viruses) from boats directly discharging into marine water recreational areas is very possible. Floating waste has been reported during this survey.

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#82/1983

Systems		Water- shed in Acres	Class Water (5)	Stnds. Ex- ceeded ⁽⁶⁾	DNR Water Quality Stations	Bay Type (7)
Septic Tank	Plant Outfall					
		1,092	C	yes	42, 43, 44	Partly Closed
		656	C	no	40, 41	Partly Closed
x		472	B	no	8, 9	Open
		752 ⁽²⁾	C	yes	32A-B, 33, 34, 35	Partly Closed
		148	B	no	31A	Open
		162 ⁽²⁾	C	no	37, 38	Partly Closed
x		40	B	no	40	Partly Closed
x		90	B/C	dna ⁽⁴⁾	None	Partly Closed
x		200	B	yes	26A	Partly Closed
	x	2,725	B	yes	27A, 27B	Restricted
N.A.	N.A.	N.A.	B	no	27F	Partly Closed
x		390	B	yes	26B, 27C	Restricted
x		60	B	no	24	Partly Closed
x		276	B	dna	None	Partly Closed
x	x	281	B	yes	22A, 22B	Partly Closed
x		242	B	yes	43A, 43B	Partly Closed
x		28	B	yes	43C, 43D	Partly Closed

agoon between

(6) V.I. Water Quality Standards for fecal coliform or Secchi depth exceeded once or more since beginning of 1979.

(7) Derived from Ref. 11, except for St. Croix sites which are

TABLE 8. Water Quality Factors at Anchorages.

ANCHORAGE	Total Boats	Live Aboard	Shoreline Developm't.			Sewage Systems			Water-shed in Acres	Class Water (5)	Stnds. Ex-ceeded ⁽⁶⁾	DNRW Water Quality Stations	Bay Type (7)
			Dense	Med.	Low	Several	Septic Tank	Plant Outfall					
X'sted.-West	80	23	x			x			1,092	C	yes	42, 43, 44	Partly Closed
X'sted.-Gallows Bay	76	13	x			x			656	C	no	40, 41	Partly Closed
Tague Bay	91	12			x		x		472	B	no	8, 9	Open
Long Bay	296	203	x			x			752 ⁽²⁾	C	yes	32A-B, 33, 34, 35	Partly Closed
Pacquereau	35	(14) ⁽¹⁾		x		x			148	B	no	31A	Open
Frenchtown	55	14	x			x			162 ⁽²⁾	C	no	37, 38	Partly Closed
Honeymoon	13	(5) ⁽¹⁾			x		x		40	B	no	40	Partly Closed
Elephant	58	23			x		x		90	B/C	dna ⁽⁴⁾	None	Partly Closed
Lagoon-Benner	184	61	x				x		200	B	yes	26A	Partly Closed
Lagoon-Head	0	0		x				x	2,725	B	yes	27A, 27B	Restricted
Lagoon-False Entrance	19	17	None ⁽³⁾			N.A.	N.A.	N.A.	N.A.	B	no	27F	Partly Closed
Lagoon-North Shore	108	8		x			x		390	B	yes	26B, 27C	Restricted
Cowpet	58	1		x		x	x		60	B	no	24	Partly Closed
Red Hook/Muller	26	20			x		x		276	B	dna	None	Partly Closed
Vessup	170	58		x		x	x	x	281	B	yes	22A, 22B	Partly Closed
Cruz Bay-Main Harbor	53	32		x		x	x		242	B	yes	43A, 43B	Partly Closed
Cruz Bay-Creek	22	0	x			x	x		28	B	yes	43C, 43D	Partly Closed

(1) Estimated, all others actual counts.

(2) Total drainage area into harbor = 1,458 acres.

(3) Anchorage in outer lagoon between mangrove islands.

(4) Data not available.

(6) V.I. Water Quality Standards for fecal coliform or Secchi depth exceeded once or more since beginning of 1979.

(7) Derived from Ref. 11, except for St. Croix sites which are

It is, therefore, recommended that the Marine Sanitation Device Regulations of the Clean Water Act be enforced to a greater extent in the U.S. Virgin Islands. Since the greatest percentage of small vessels in the Virgin Islands are 65 feet or less in length, the Type I MSD would be applicable.

The Type I device contains macerating equipment which chops sewage matter into small particles which when discharged into the water readily disperse and can be acted upon more effectively by natural disinfecting agents in a much shorter time. Most of the coastal embayments in the Virgin Islands experience reasonably good tidal and wave driven flushing action required to disperse and dilute sewage and to minimize its nuisance value and health hazards. Such dilution and dispersal also minimizes nutrient build up.

In order to implement this recommendation, an interagency agreement is suggested between the U.S. Coast Guard and the Virgin Islands Department of Conservation and Cultural Affairs (Bureau of Environmental Enforcement) to transfer authority for enforcement of the federal Marine Sanitation Device Regulations to the territorial agency.

2. LAND BASED SOIL EROSION CONTROL.

The present Virgin Islands Earth Change Program is in-operative and is in need of new direction and restructuring. Further research is also recommended to determine erosion rates and nutrient values of various soils in appropriate watersheds.

B. Site Specific Management Approach.

While most bays utilized by the boating public are sufficiently well flushed so that the Type I MSD's are adequate, there are a few semi-enclosed bays and harbors which, because of their sheltered location and the availability of land based support facilities, have become the most sought after small vessel mooring, anchorage and docking locations. These generally are host to a significant proportion of live-aboard vessels (40 to 70 percent). Invariably, due to their shallow, sheltered geographical configurations, these bays receive minimal flushing, insufficient to prevent the deterioration of water quality.

However, of much greater significance are the land based pollution sources frequently also located in proximity to

these anchorages. Such sources are generally sewer plant discharges, raw sewage discharges from broken lines, malfunctioning pumping stations, illegal commercial, industrial and domestic discharges, and septic tank leach fields in proximity to the shoreline. Superimposed on such inputs to these embayments or lagoons is the periodic infusion of storm runoff from adjacent developed urban or residential watersheds. Table 8 includes a summary of the primary pollution sources at each study site. Some sources, such as sewage plant effluents and vessel wastes, could be reasonably well quantified; while others, like storm runoff, leaking sewers and septic tank drainage, could not be quantified but could be inferred from nearshore water quality surveys performed over a number of years by the Department of Conservation and Cultural Affairs.

As a consequence of the diverse, diffuse and multiple source pollution inputs affecting selected anchorages, a site specific management approach is recommended as more appropriate and likely to accomplish desired objectives than a comprehensive, standardized territorial approach.

The following discussion of each anchorage or harbor (study site) provides a general description of the site, the principal pollution impacts and site specific management recommendations. It should be noted that the management recommendations are relevant to the conditions as they were found at the time of the current study. Should changes occur over time, then modifications in the recommended mitigation or management strategies may be in order.

The site specific management recommendation addresses only some of the more obvious and pressing mismanaged situations which were identified during the course of this effort. The larger issue of comprehensive resource management (of watersheds, bays, coastlines, marine users and uses, etc.) was beyond the scope of this study. However, it does need to be addressed as a high priority territorial planning and management task.

The Virgin Islands Coastal Zone Management Act has been identified as the appropriate existing legislation which could deal with the larger issue of resource management. The act contains the provision for the establishment of "Areas of Particular Concern" (hereinafter referred to as APC's), which in essence are site specific management plans for heavily used, highly stressed or otherwise important or valuable coastal sub-units or locations, usually coastal embayments (including lagoons and harbors) and their

associated watershed. APC plans are to be prepared by the Department of Conservation and Cultural Affairs and must be approved or adopted by both the Virgin Islands Coastal Zone Management Commission and the Virgin Islands Legislature.

It should be pointed out, however, that the authority provided by the Virgin Islands Coastal Zone Management Act for the APC planning and management process is limited to the first tier of the littoral portion of the coastal zone, a relatively narrow band of land of varying width along the coastline. The exact dimensions of the first tier are delineated on the official Virgin Islands Coastal Zone Maps. Most watersheds which must be included in the APC plans, however, extend inland beyond the first tier, outside the jurisdiction of the V.I. Coastal Zone Management Program. An amendment of the V.I. CZM Act would be desirable if a comprehensive management approach is attempted.

One alternative to this involves a modification in the Virgin Islands Planning Office's comprehensive land use management planning strategy and the structuring of an interdepartmental, "consistency" sign-off procedure for all development and permitting activity.

Two draft DCCA APC plans, for the Mangrove Lagoon and the Vessup Bay/Red Hook area, have been prepared but never finalized or approved. The CZM Act and the APC plans are discussed below in Section VII, "Analysis of Extant Legislation and Programs."

Since this study examined not only vessel wastes but also other pollutant sources, it should be noted that the largest and most significant pollution generated is not from boats but generally from land based sources as is described in the discussions of specific anchorages which follow. When viewing an embayment or anchorage as a management unit, all of the pollution sources need to be reduced or mitigated to a level which is deemed acceptable in the aggregate. Management strategies designed to achieve this objective must be practical, fair to each user group, economically defensible, and susceptible to cost-effective, quantitative environmental quality control and monitoring procedures by DCCA/DNRM.

1. CHRISTIANSTED.

Although the overall harbor contains a relatively large surface area of 570 acres, only a small portion of about 30 acres serves as a concentrated, protected yacht/small vessel anchorage. This anchorage area is largely located west of Protestant Cay, while the principal boat docking area is located to the east of Gallows Bay at St. Croix Marina with some lesser docking along the boardwalk west of Fort Christiana. Water monitoring stations are located within or near the three boat concentration areas noted above (DCCA/DNRM stations 40, 42, and 44). The harbor surface currents have a general counter clockwise direction in the harbor and would carry some portion of boat pollutants (sewage) to the west around Protestant Cay (1). However, due to slow current velocities, the settleable fraction of the waste would normally be deposited on the harbor bottom.

The land based pollution sources entering Christiansted Harbor include surface run-off with its sediment, nutrients and other pollutants (3), and intermittent sewage discharges occurring about one or two days a month when problems occur with the sewage lift station (personal communication with G. Golden, CZM/DCCA). In 1973 the nearshore areas of the central and eastern harbor contained eutrophic Enteromorpha dominated alga communities, likely the result of the aforementioned pollutant sources (3).

The present situation should not be expected to have improved as the above mentioned pollutant sources are still active. The nearshore DCCA/DNRM water quality stations (40, 41, 42 and 43) indicate the highest pollution level of all the stations (total of 15) in the harbor area (4).

The Gallows Bay area, the major commercial portion of the harbor, has suffered extensive shoaling from land derived sediments, and the original dredged depth of 16 feet has been reduced to four to six feet (1). Current direction is in a general clockwise direction with low velocities (not more than 0.1 m/sec.) (1). Water quality measurements do not vary greatly from the other nearshore monitoring stations, indicating a generally stressed aquatic environment (1). The Gallows Bay area receives drainage from a 656 acre watershed, while the drainage from the urbanized Christiansted town area drains from about 1,092 acres (note that this includes, however, the less developed areas of Golden Rock and Orange Grove) (14).

a. Christiansted (West of Protestant Cay). The anchorage west of Protestant Cay contains about 50 boats of which seventeen are possible live-aboards (34 percent), while the docks and piers along the waterfront contain at least 30 boats of which six were found to be live-aboards (20 percent). Two DCCA/DNRM water quality stations are located in the boat areas -- no. 44 in the mooring/anchorage area and no. 42 near the docked boats. The two stations reveal markedly different water quality analysis results. Station no. 44 with the larger number of boats and live-aboards (50 boats, 17 live-aboards) indicates very low pollution levels: fecal coliform 1980 mean of 1 per 100 ml, 1981 mean of 3, while turbidity respectively was 1 and 1.5 NTU. Station 42, close to the docked boats and closer to shore, shows consistent, relatively high fecal coliform counts: 1980 mean of 118, 1981 mean of 208; likewise, higher turbidity levels (1.8 and 2.1) than at station no. 44. Yet, of the 30 docked boats counted, only six were found to be occupied. Clearly, this inverse relationship between number of live-aboard boats and water quality suggests the live-aboard boats are not a significant pollution source, but that the poor water quality at the near-shore station is the probable result of land based uses, the intermittent sewage overflow mentioned above being one of them.

Nevertheless, it has been reported that floating sewage matter is occasionally present in the area west of Protestant Cay, possibly the result of direct discharge from live-aboard boats (personal communication, Roy Adams, Director of Planning). Depending on tidal current and wind direction, such floatables could easily result from the periodic overflow/discharge of Christiansted's municipal sewage system through storm drains into the harbor. Intact fecus are rarely discharged by boat heads and are more likely the product of domestic flush-type toilets which transfer all wastes intact into the sewer lines.

MANAGEMENT RECOMMENDATIONS:

- (i) Resolve sewage pumping problem in Christiansted.
- (ii) Conduct further investigation to determine cause of poor near shore water quality and possible elimination of these sources.
- (iii) Develop effective soil erosion control strategies to limit overall nutrient impact into harbor due to soil transport.

- (iv) Require Type I MSD on all boats which are used as live-aboards.
- (v) Identify and seal or remove all illegal sewage and waste discharge pipes along the waterfront area.

b. Christiansted (Gallows Bay - East of Protestant Cay). The Gallows Bay area, including St. Croix Marine, Inc. marina, contains 56 docked boats, ten of which were found to be live-aboards and 20 anchored/moored boats with three live-aboards. DCCA/DNRM water quality station no. 40 is located in proximity to the marina which contains most of the live-aboard boats. Fecal coliform are present in the samples, 41 per 100 ml, 1980 mean and 30 per 100 ml, 1981 mean. Since the station is also close to shore, the contamination source or sources cannot be pinpointed. Station no. 41 located inside the Gallows Bay commercial harbor area, and also the drainage terminal point of a 656 acre watershed, shows fecal coliform counts and turbidity in the same range as station no. 40 at the marina. This suggests continual contamination from land based sources, although sewage discharges from freight vessels utilizing the Gallows Bay dock should not be discounted.

MANAGEMENT RECOMMENDATIONS:

- (i) Further investigation to determine cause of poor near shore water quality and possible elimination of these sources.
- (ii) Effective soil erosion control to minimize sedimentation of Gallows Bay and reduce overall nutrient input into coastal waters due to soil transport.

2. TAGUE BAY.

The bay encompasses about 113 acres of which a lesser portion is utilized for boat anchorage. The bay is located on the northeast shoreline of St. Croix and is protected from open sea swells by a fringing reef. Although the reef has received close examination, especially by West Indies Laboratory researchers, very little published information exists on the inner bay and its secular water quality parameters. The bay shoreline is mostly beach sand and is utilized for water contact recreation. The bay is generally less than 20 feet deep, and the bottom is mostly covered by sand and sea grasses.

Three substantial piers serve the West Indies Laboratory, the St. Croix Yacht Club, and the Reef Bay condominiums. The Yacht Club pier contains most of the docked boats in the bay where ninety-one boats were counted in January 1983, with fifty moored or anchored and forty-one docked. The DCCA count in March 1981 indicated sixty-one boats moored. Information on docked boats was not available for that date; however, the July 1980 count indicates forty-two boats. It is obvious that the number of vessels is increasing.

Two DCCA/DNRM water quality stations (nos. 8 and 9) are located in the bay and have indicated generally good water quality. Currents (within the bay) are primarily from the west and appear to flush the bay quite well due to its large opening to the sea and currents derived from external wave, wind and swell patterns which, of course, vary over time.

Significant pollution sources do not exist except during heavy rainfall when suspended terrestrial materials from two smaller watersheds are discharged into the bay. The overall environmental condition of the bay is considered good according to Dr. Caroline Rogers, DCCA/DNRM (St. Croix).

The Tague Bay anchorage contains 50 anchored/moored boats of which twelve appear to be live-aboards and 41 docked boats with no live-aboards. The monthly BOD loading from the live-aboards is 23 lbs. Due to the few live-aboards and substantial natural flushing capability of the bay, the boating pollution source is negligible. However, a sandy recreation beach is nearby, and floating sewage solids would interfere with water contact recreational activities. DCCA/DNRM's water quality stations no. 8 and 9 have not shown any water quality degradation over time. However, heavy rainfall runoff has resulted in temporary lowering in the ambient water quality.

MANAGEMENT RECOMMENDATIONS:

- (i) Effective soil erosion control to limit nutrient and sediment input into the bay.
- (ii) Type I MSD on all live-aboard boats.

3. CHARLOTTE AMALIE.

The primary harbor area contains 0.72 square miles (1.86 km²) and includes three principal anchorages -- Pacquereau Bay at the harbor entrance on the southeastern segment; Long Bay, the principal vessel anchorage and docking area in the northeastern sector; and on the northwestern portion, the so-called Frenchtown anchorage. Previous aerial boat counts indicated, respectively, 35, 326, and 95 boats docked and moored, using the higher figure in the two counts taken (on July 15, 1980 and March 14, 1981).

The principal marina, Yacht Haven, in Charlotte Amalie is located in Long Bay with 175 slips; a smaller marina, Avery's, is located on the edge of Frenchtown with 35 slips. Other minor anchorages are dispersed through the harbor, particularly off the north shore of Hassel Island and in the East Gregorie Channel. Freight and passenger ferries and larger yachts, small naval and research vessels and local fishing boats customarily tie-up along the length of the waterfront bulkhead on the harbor's northern perimeter.

DCCA/DNRM maintains eleven water quality stations in the harbor, with three stations in the general Long Bay anchorage, one in Pacquereau Bay and two at the Frenchtown anchorage (4). Water quality and the general environmental state of the harbor have been summarized, with additional data, in a very recent environmental impact study for the proposed waterfront highway expansion project through Charlotte Amalie (18). The inner harbor environment is biologically stressed with low species abundance and diversity. The findings indicate a deterioration since 1974. Improvements since 1973 when the raw sewage outfalls were terminated have only been noted in turbidity (Secchi depth) and dissolved oxygen at lower water depths (18).

The discharge of terrestrial pollutants from the urbanizing watershed, including large quantities of clays and silts, vehicle parts and tires, waste oils from vehicles and service stations, broken sewers, cleaning fluids, municipal wastes, restaurant wash water, and general street debris, contribute significantly to the continual harbor pollution.

Additionally, large vessels (cruise ships, tugs, and cargo carriers) repeatedly stir up the fine bottom sediments, while smaller boats add their pollution through sewage discharge and other activities (18).

During October of 1980 a series of water samples were taken at storm drain outfalls in the harbor by DCCA/DNRM which indicated extremely high fecal coliform counts, several close to 1×10^6 per 100 ml. It suggests significant leakage of sewer lines; however, a more comprehensive quantitative assessment of non-vessel derived harbor pollutant input is required before a comprehensive plan can be developed on the basis of known variables.

General harbor currents are driven principally by the near-shore component of the North Equatorial Current and wind driven waves, while tides are estimated to account for only a small fraction of the harbor water exchange, the tide prism being only 2.8 percent of the harbor water volume. Surface currents enter the main harbor entrance, sweep past Pacquereau Bay and follow a net counterclockwise pattern through the harbor (18).

During flood tides, currents exit through Haulover Cut out into Gregory Channel, while reversing the flow on ebb tides. Bottom currents follow a reverse pattern to surface currents, but are more complex and variable (18).

A more or less permanent eddy current exists in Long Bay, tending to entrain pollutants. Current velocities are generally low in the harbor, ranging from 0.16 to 0.34 ft./sec. (18).

The harbor is designated as Class "C" water under the Virgin Islands Water Quality Standards.

Brief water quality discussions can be found in items 9 and 19 which are cited in the reference section of this report.

a. Long Bay, Charlotte Amalie Harbor. The Long Bay anchorage contains at least 155 boats of which 145 appeared to be occupied; of the 141 docked boats counted, 58 appeared to be live-aboards.

One recurring situation existed practically at all the study sites; empty docking slips or moorings were always present. Yacht Haven Marina has 175 total docking slips, of which only 141 were occupied during the present survey. Thus, while anchorages or mooring areas have a potential for a given number of boats, there is always a percentage of slips not occupied, principally because the tenant vessel is out cruising or hauled out for maintenance. Most marinas have no unrented slips or dock space.

The Yacht Haven Marina was found to be unique in its enforcement of prohibition against the discharge of vessel holding tanks while docked at its piers; reportedly several vessels found violating this requirement were refused further dockage at the marina (personal communication, John Agnew, marina manager). Compliance, however, is more the result of peer pressure from other boaters than through enforcement inspection by marina authorities, which is consistent with the general attitude found during the survey -- namely, that persons who reside on boats are generally speaking more environmentally "sensitive" than land dwelling persons. Clearly, at the Yacht Haven marina (as with others) violations do occur; however, the general trend is a lower sewage input into the receiving water than at other marinas without such a policy. Obviously, convenient, user-acceptable toilet facilities must be available twenty-four hours a day. The marina is also planning to install two sewage pump-out stations, available free of charge to vessels at the marina and for a modest fee to visiting boats.

The total BOD loading from the anchored/moored as compared to the docked boats is significantly different and reflects the higher percentage of live-aboards on moored boats (94 percent) to 41 percent docked live-aboards -- which was the same trend at all of the anchorages reviewed. While the total moored/anchored boats counted (155) were only slightly higher than the docked boats (141), the total BOD contribution from the moored vessels was found to be over 3.5 times that of the docked vessels: 5,360 lb./year to 1,530 lb./year (reference Table 6).

There are three DCCA/DNRM water monitoring stations in the Long Bay area, nos. 32A, 33, and 34. The first two show poor water quality with the class C water quality limits of 1,000 fecal coliform per 100 ml having been exceeded a number of times during sampling. The inner harbor contains 9 sampling stations for which the monthly results over a two and a half year period were available (1978 through June 1980). These afforded the opportunity to examine the spectral and temporal data variability. Further, daily rainfall records for that time period for Charlotte Amalie were also accessible (15).

The fecal coliform data showed significant high values for certain stations for three monthly samplings: 3/20/79, 8/1/79 and 11/9/79. The fecal coliform values of the nine stations are shown below in Table 9.

STATION SAMPLING DATE	RAINFALL		S T A T I O N S								
	Inches	Date	31C	32A	32B	33	34	35	36	37	38
3/20/79	2.01	3/17	No Data	210	>2,000	3	Neg.	3	8	7	22
	0.63	3/18									
8/1/79	0.24	8/1	5	> 200	2,000	> 2,000	Neg.	> 200	> 2,000	> 200	Neg.
	1.31	11/8									
11/9/79	0.52	11/9	4	282	1,100	2,900	40	35	800	232	8
1979 Mean			4	89	550	429	21	24	278	56	5

TABLE 9. Charlotte Amalie Harbor Coliform Counts per 100 ml
During Storm Events.

The spatial variability of fecal coliform density is noticeable. The locations with the three highest densities are stations no. 32B, 33 and 36 both for the peak events and the yearly mean. The peak event also occurred on days of rainfall when runoff occurred. Interestingly, antecedent rainfall for sampling day 3/20/79 occurred two and three days prior, with coliform densities significantly lower than the other two sampling days, with the exception of station no. 32B. The lower counts on 3/20/79 suggests dilution and dieoff of bacteria. However, the concentrations are still significantly higher at most of the stations than the yearly means. A possible explanation is the spread of the pollutant throughout the harbor resulting in large coliform density increases at stations 32A and 38 (the West Indian Company dock and Haulover Gut, respectively). However, substantial additional data must be available to fully document such a possibility.

A few tentative conclusions can be drawn from the limited data available:

- * Peak pollution episodes occur when rainfall occurs producing runoff.
- * Major pollution sources appear to be located at the east and west Long Bay storm drain outfall and at the storm drain by the Coast Guard dock.
- * Coliform levels remain relatively high for at least two days after a runoff event and seem to be dispersed throughout the harbor.
- * The above represents only the coincidence between rainfall events and sampling efforts; thus, aggregate runoff carrying pollutants could be much higher. During 1979, 55 days occurred where rainfall less than 0.5 was recorded and 29 days with 0.5 inch or more rainfall. Thus such pollution events could have occurred at least 29 times during the year and possibly a maximum of 84 times. The unknown factor is the rainfall level (or rate) at which runoff will occur, perhaps as low as between 0.1 to 0.25 inches. In any event, it appears that runoff pollution is significant both in terms of frequency and intensity and very likely is the principal cause of poor water quality in Charlotte Amalie harbor.

It would appear that the pollution contribution, mainly from the moored/anchored vessels is a low level, steady input to which is added the frequent, high intensity, high volume input from land drainage. What is not clear is the specific source or sources of the land based fecal coliforms. The possible sources include private sewage discharges, privy seepage, surreptitious night soil disposal in guts, breaks in underground sewers, illegal commercial waste, and overflows from storm drains and/or sewage dumps.

MANAGEMENT RECOMMENDATIONS:

- (i) Given the previous experience of the Yacht Haven Marina discouraging direct vessel discharge and encouraging the use of the sewage pump-out facilities, it may also be useful to establish a temporary water quality monitoring station to determine if the no discharge policy and the pump-out facility have produced noticeable beneficial water quality effects.
- (ii) Identify the sources of the land based pollution sources (fecal coliform) and eliminate the same.
- (iii) Sewage discharges from anchored/moored vessels need to be eliminated due to low flushing capability of the bay and current eddy in Long Bay.
- (iv) Prohibit sewage discharge from any cruise ships or other larger vessels.
- (v) Control terrestrial soil erosion to minimize nutrient and sediment input into the harbor.

b. Pacquereau Bay, Charlotte Amalie Harbor. The Pacquereau Bay site is one of the smaller anchorages on the eastern edge of the main harbor entrance to Charlotte Amalie, below the Frenchman's Reef Hotel. Of the approximately 35 total boats located there, 38 percent or about 13 are estimated to be live-aboards, with a monthly BOD load of about 4.3 pounds.

The proximity of this site to the harbor entrance produces excellent flushing action, and with relatively few live-aboards or other significant pollution sources, water quality in the bay has not been seriously affected. DCCA/DNRM water

quality station no. 31A has shown consistently good water quality conditions over the eight years (1973-1980) for which data is available. Fecal coliform counts are all negative, while turbidity has remained below 1 FTU, consistent with the values found in the well flushed south coast bays of St. Thomas. The land watershed is very small (138 acres) with light to medium dense (primarily residential) development, thus causing low level, land based pollution loads during storm runoff. A sand beach with some recreational potential is located in the bay, and floatable waste from occupied boats not equipped with Type I heads (i.e., mastication) may float toward the beach during occasional periods of onshore winds from the south and west.

MANAGEMENT RECOMMENDATIONS:

- (i) Require Type I MSD's on all boats which are used as live-aboards.

c. Frenchtown - Western Reaches of Charlotte Amalie. Boat counts in the Frenchtown anchorage area revealed 21 anchored/moored boats of which eight appeared occupied; while of the 34 docked, 13 were small open fishing boats and six were apparently live-aboards. The BOD loading from all the live-aboards is 290 lbs./per year.

The data from the two DCCA/DNRM water quality stations (nos. 37 and 38) shows relatively better water quality than the inner portions of the harbor, although measurable pollution levels are still present. Station no. 37 shows a fecal coliform density mean for 1979 of 56 per 100 mililiter; while station no. 38 shows 5 per 100 mililiter. The data gives no exact indication of the pollution source; however, it should be noted that the predominant harbor current discharges westerly through Haulover Cut, thereby placing station no. 37, with the higher coliform counts, upstream of the Frenchtown boat concentration. It would appear from the data that these boats are not a significant pollution source.

As noted in section (a) above concerning Long Bay, the lower pollution levels at the Frenchtown harbor area are possibly the result of dispersion of pollutants from the high level pollution sources at Long Bay. However, intermittent pollution sources are also present in the Frenchtown area like the raw sewage overflow from the drainage ditch adjacent to the Quarter Deck restaurant, a situation which apparently existed for several months during 1982-83. The ditches west of the post office and east of the airboat terminal are also an intermittent source of pollutants of several types.

The watershed draining into the western most portion of the harbor is relatively small, about 270 acres, and is partially developed, primarily with medium density residential and commercial uses. Although the pollution contribution to the harbor from this area cannot be quantified with available data, it appears to be less than the areas draining into the eastern portion of the harbor. Furthermore, it can be expected that the steeper, still forested hills above the town, north and east of the waterfront, will experience continual development with proportionally greater soil erosion due to the steepness of the terrain.

MANAGEMENT RECOMMENDATIONS:

- (i) Require Type I MSD's on all live-aboard boats.
- (ii) Implement effective soil erosion control to limit nutrient and sediment input into the harbor.

4. HONEYMOON/ELEPHANT/RUYTER BAYS.

Honeymoon and Elephant Bays are located on the northwest shore of Water Island. Honeymoon (also known as Druif Bay, Druif being Grape in Danish) is a well defined embayment of 23 acres with water depths of 10 feet or more for most of the bay (17). Elephant Bay, including Ruyter Bay for the purpose of this survey, is not well defined as an embayment and is located on the leeward side of Water Island providing a reasonably sheltered anchorage area.

The highest counts by DCCA in 1980 and 1981 indicated 13 boats in Honeymoon Bay and 31 in Elephant Bay, all moored or anchored. No marinas are located at these sites. Honeymoon Bay is a popular swimming beach and is a stop-off point for local tourist day or partial day commercial group tour boats such as the Kon-Tiki. Honeymoon Bay currently has one DCCA/DNRM water quality monitoring station, which has shown good water quality with an occasionally high Fecal Coliform count and elevated turbidity (5).

Elephant and Ruyter Bays are located on the southerly shoreline perimeter of West Gregorie Channel, a heavily utilized ship channel serving the commercial/industrial Subbase and Crown Bay waterfront areas. Currents through the channel flow predominately westerly through the harbor and East Gregorie Channel, exiting out of the West Gregorie Channel. Although occasionally a reverse flow has been observed, current velocities are generally low (23).

The ship channel is generally devoid of significant benthic organisms, but the northwestern shoreline area of Water Island (including Elephant and Ruyter Bays) contains some seagrass communities as well as living coral assemblages (20). Detailed studies of these anchorages are not available.

b. Elephant and Ruyter Bays. Fifty-eight (58) moored/anchored vessels were found in the Elephant/Ruyter Bay anchorage, with about 23 live-aboards. The live-aboard boats contribute approximately six pounds of BOD per month to the receiving water. The watershed from Water Island is broken into several smaller segments which total 90 acres; land based development is very low density residential.

Due to the exposure of the anchorage to the currents passing through West Gregorie Channel and the absence of any water contract recreation areas, no specific management recommendations are made for this site.

5. MANGROVE LAGOON/BENNER BAY.

The Mangrove Lagoon has a surface area of 152 acres, while the Benner Bay anchorage contains about 34 acres. Boats are densely packed along the shoreline in and around Benner Bay toward the new race track area. Boats large enough for living aboard are confined to the Benner Bay area due to depth limitations in most other parts of the interior of the Lagoon. A small contingent of live-aboard boats is also located at Bovoni and Cas Cays (the "false entrance" area), about 22 boats in number (29). The total Lagoon area contains 481 boats, including those stored or under repair on land (158 boats). The Benner Bay anchorage contains 73 boats, and docked boats accounted for 130 (26). The 120 smaller, privately docked boats in the Lagoon were not included in the survey as they generally are located in the shallower areas of the lagoon which limits the size of boats and generally precludes live aboards to any large extent.

The Lagoon contains eight DCCA/DNRM water quality stations with one station (# 26-A) situated directly in Benner Bay (4). Tidal currents enter principally through the Benner Bay west entrance and exit through the Cas Cay entrance reach. When wind and mass wave transport currents are weak, tidal currents are the primary driving force responsible for water exchange (29). The Mangrove Lagoon is characterized as "restricted" with poor flushing (11).

The Lagoon has four, perhaps five, significant pollution sources: 1) high boat concentration and boat maintenance facilities in Benner Bay; 2) major storm drainage input from Turpentine Run; 3) Nadir sewage treatment plant out-

fall; 4) leachate and surface runoff from the solid waste disposal site; and 5) general runoff from the highly developed residential, steep hillsides on watersheds other than the Turpentine Run Gut.

The adverse effect on water quality and lagoon ecosystems has been well documented in several studies (27, 28). Conservative pollutants in sediments such as trace metals and hydrocarbons were found in significant concentrations at both the lagoon head, where the treatment plant and Turpentine Run discharge, as well as in Benner Bay, the boat anchorage and maintenance facility. The lagoon head is experiencing eutrophication resulting from high concentrations of nutrients discharged from the Nadir treatment plant as well as inland treatment plants in Tutu which discharge into Turpentine Run (27, 28). The impact of the solid waste disposal site remains unquantified.

An additional general discussion of the Benner Bay environment can be found in items 8 and 9 in the reference section below.

For the purposes of this study, the Mangrove Lagoon has been divided into several sub-units: Benner Bay, the lagoon head, the coastal stretch between Benner Bay and the head referred to as the North Shore, and the outer portion, i.e., the seaward southeasterly area of Bovoni Bay usually referred to as the False Entrance. For ready reference the vessel information from Table 7 is presented in modified form on page 47, with the North Shore information provided separately and BOD shown as monthly values.

The higher numbers and percentage of live-aboard vessels are found in the anchored or moored areas. While the coastal strip -- or the North Shore -- has a fairly large number of boats, few were found to be live-aboards, and those were primarily toward the deeper Benner Bay side of the coastal strip which accommodates deeper draft, larger vessels.

Also note that the boat counts shown in the following modified table were based on field counts in March 1983, whereas the earlier discussed boat numbers and locations were based on the referenced information.

SITE	ANCHORED/MOORED				DOCKED			
	Total #	Live-Aboards #	%	BOD lb./mo.	Total #	Live-Aboards #	%	BOD lb./mo.
Benner Bay	74	45	61%	206	110	16	15%	34
Lagoon Head	0	0	0	0	0	0	0	0
False Entrance	19	17	89%	69	0	0	0	0
North Shore	0	0	0	0	108	8	7%	17

DCCA/DNRM water quality station no. 26A in Benner Bay apparently reflects the sewage input from vessels and increased loadings from other sources. Fecal coliform counts have been steadily increasing during the years of sampling since 1973, having on a number of sampling occasions exceeded the Virgin Islands Water Quality Standards of 70 per 100 ml. (Figures 2, 3, and 4 indicate the water quality trends at three of the sampling stations which indicate the greatest degree of pollution in the lagoon.) The most recent sampling by DCCA/DNRM on February 28, 1983, reported a density of 203 fecal coliforms per 100 ml. Turbidity has likewise been on the increase and dissolved oxygen concentrations have fluctuated widely. Large diurnal dissolved oxygen concentration fluctuations in a poorly flushed, nutrient rich, phytoplankton dominated aquatic environment had been documented as early as 1970 by Grigg, et. al. in their environmental study of nearby Vessup Bay where similar conditions existed (7).

Besides the sewage/nutrient contribution from vessels in Benner Bay, the shoreline land developments around Benner Bay and along the coastal strip contribute their respective nutrient loading. Approximately 22 businesses and residential structures exist directly on the shoreline, with others on the opposite side of the road paralleling the lagoon shoreline. Almost all those facilities have septic tanks with effluent discharging but a few feet from the shoreline. While sewage may be treated to some degree (30 percent at best in most septic tanks), the total absence of any significant soil mass for sewage absorption results in almost direct nutrient discharge into the lagoon waters. While it could be argued that adjacent red mangrove stands utilize

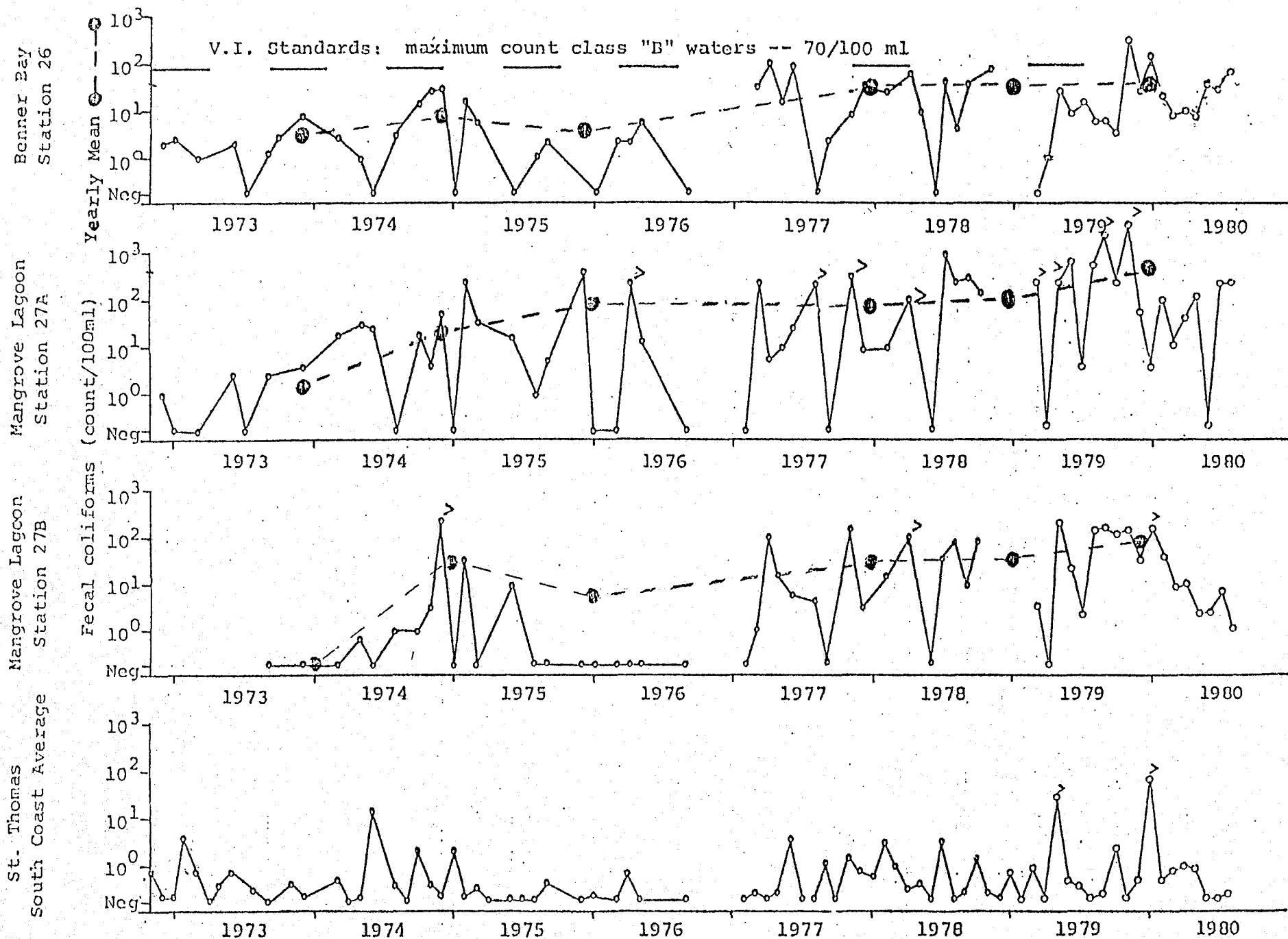


FIGURE 2,
MANGROVE LAGOON; ST. THOMAS, SURFACE WATER FECAL COLIFORMS.
Broken lines indicate data points four or more months apart.

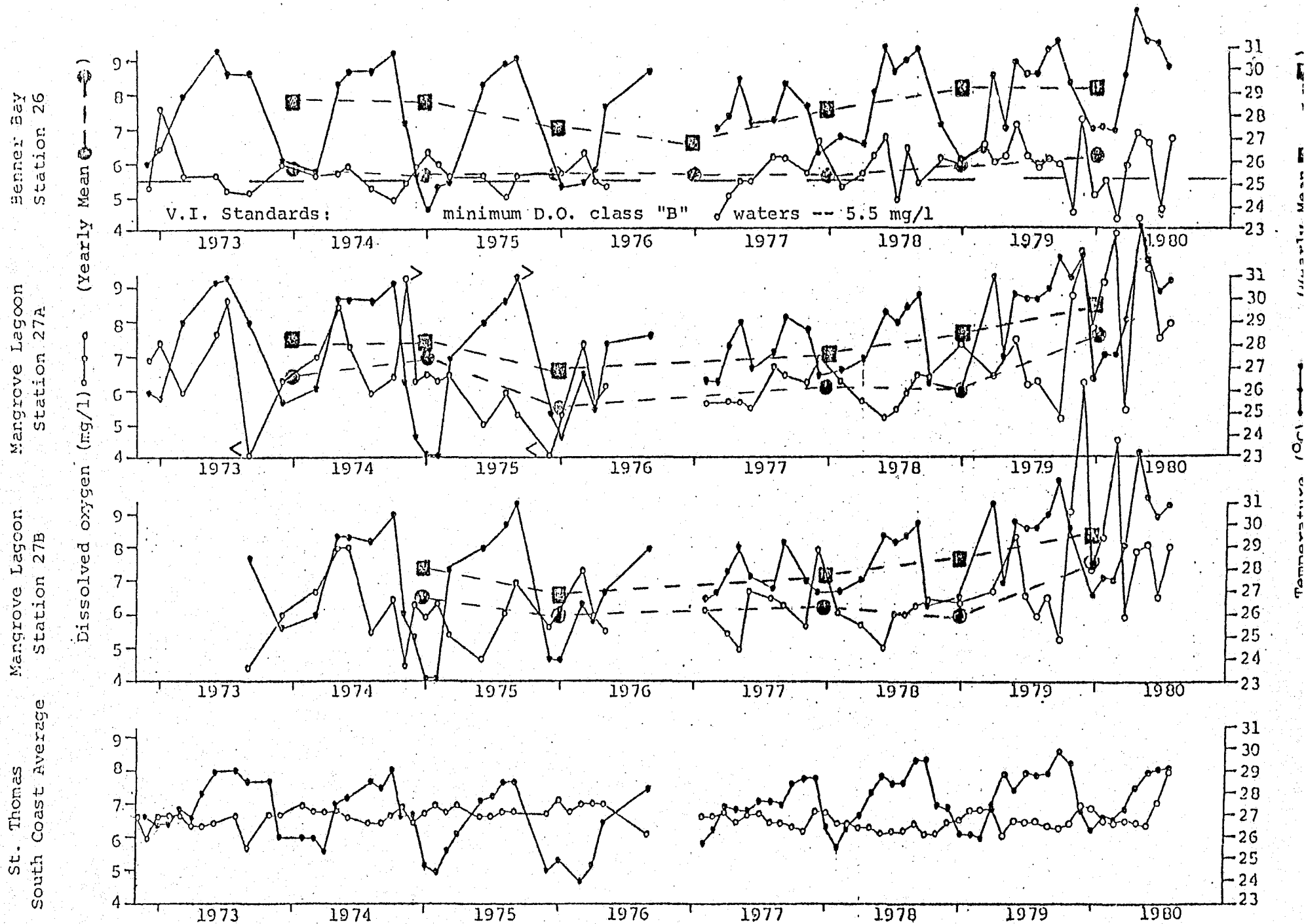


FIGURE 3.
MANGROVE LAGOON, ST. THOMAS, SURFACE WATER DISSOLVED OXYGEN AND TEMPERATURE.

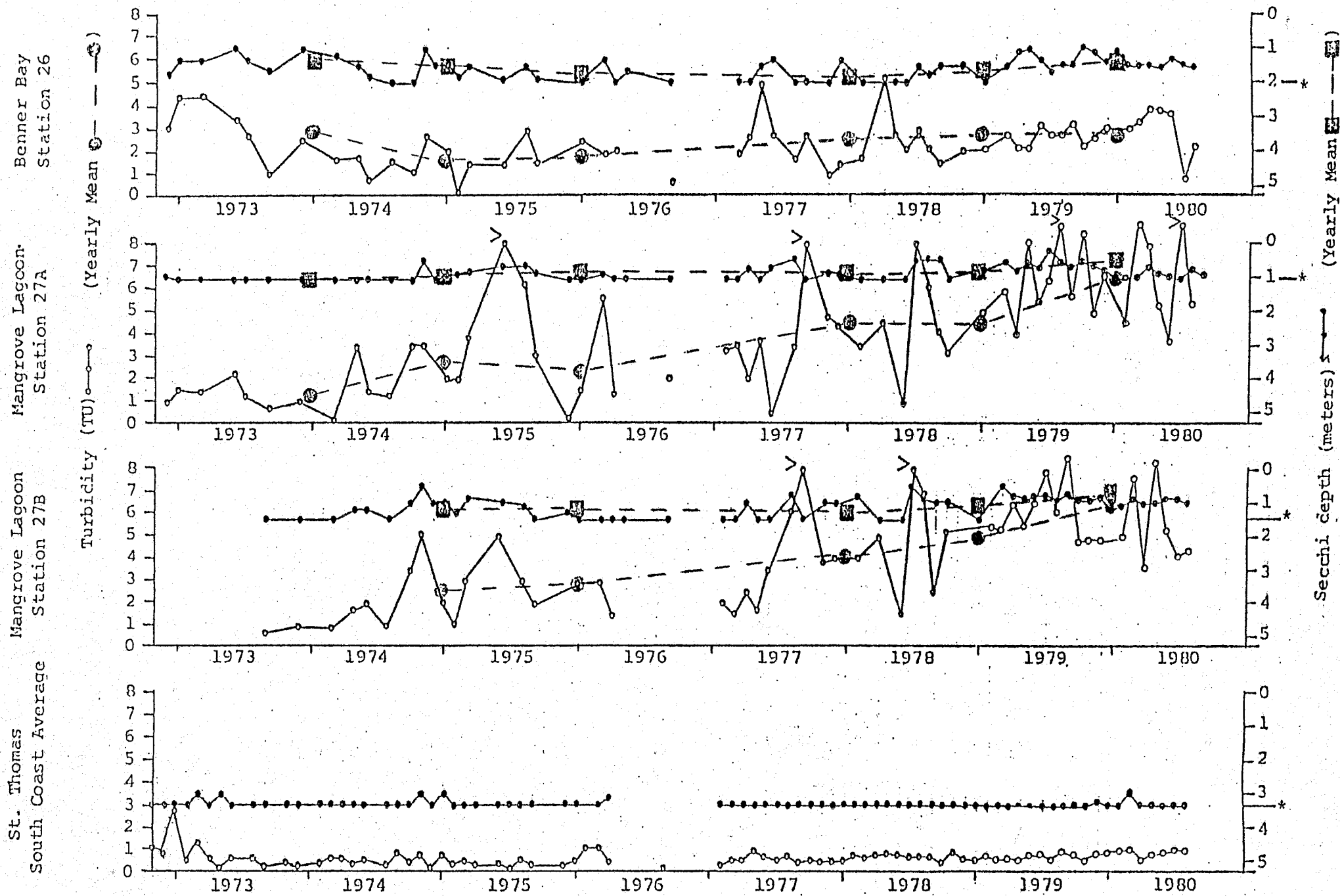


FIGURE 4.
MANGROVE LAGOON, ST. THOMAS, SURFACE WATER TURBIDITY AND SECCHI DEPTH.
Broken lines indicate data points four or more months apart. "*" indicates mean bottom depth.

some of the nutrients, their numbers are constantly diminishing due to increasing development encroachments. The only major commercial facility having a sewage treatment plant is Compass Point Marina, processing about 2,300 gpd. of sewage (39). Treated effluent reportedly is used for decorative landscape plant irrigation, but the low elevation above mean low water, the high ground water table, and the immediate proximity to the bay leaves the effectiveness of such effluent disposal practices in question, especially during periods of heavy rains. While the treatment systems of the shore development reduce the fresh sewage input indicative of fecal coliforms, the septic systems produce only minor reduction in nutrients, and it is the overall high nutrient loading which is generally responsible for the deterioration of the lagoon aquatic ecosystems. Information on the quantity of these nutrient sources is not readily available, but judging by the number of structures and general activity, it is most likely of the same order of magnitude as the nutrient contribution from the live-aboard vessel population. It may well be greater, even though less visible and more dispersed.

Examination of the water quality data for all the sampling stations readily shows that the worst condition exists in the lagoon head at stations nos. 27A and 27B. Turbidity values are very high (6.0 and 5.2 NTU, 1979 mean values, respectively); whereas other parts of the lagoon had only half these values, and the exposed south coast bays exhibited values of less than one. Fecal coliform counts showed similar trends with 1979 means of 593 and 81 for the respective stations. Most of the surrounding shoreline is heavily developed, and most of the activities are served by septic tanks. The septic tanks are often below the water table and due to the narrowness of the parcels are generally located immediately at the shoreline.

While the Lagoon Head contains no vessels, principally due to its shallowness, it is the discharge point for both the Nadir sewage plant and the Turpentine Run water course, which also receives effluent discharge from at least three publicly owned treatment plants. In February of 1983, BOD and TSS (total suspended solids) determinations were made by DCCA/DNRM of the sewage plant effluent and of the base flow of the water course discharge, which were found, respectively, to be 240 mg/l BOD, 94 mg/l TSS and 90 mg/l BOD, 6 mg/l TSS.

The Nadir sewage plant has an approximate hydraulic flow of 200,000 gpd, although the planned design capacity is only 170,000 gpd. Thus, it is overloaded as is indicated by the high BOD of the effluent. A properly operating

The principal adverse impacts threatening the coral and reef communities on the northwest shore of Water Island are turbidity and sedimentation, resulting from prop-wash of large commercial vessels (especially cruise ships, water and oil barges, and tugboats) and terrestrial sources from St. Thomas, such as storm runoff and landfill activities at the subbase area managed by the Virgin Islands Port Authority. Anchored boats contribute incidentally to the destruction of grass beds and corals through the repeated emplacement of anchors and the movement of anchor chains in cases where anchorage over such areas occurs.

The West Gregorie Channel area is designated as Class "C" water; however, the anchorage sites apparently enjoy better water quality than the limits of Class "C" water, except for ephemeral turbidity problems caused by the deep draft larger vessels.

a. Honeymoon Bay. During the vessel survey thirteen boats were counted with five estimated as live-aboards; all boats were either anchored or moored.

Examination of very recent DCCA/DNRM water quality data (December 1982, January 1983, and March 1983) have all shown negative fecal coliform counts; while turbidity, except for the March sampling, remained below 1 NTU. That high turbidity count is likely the result of the uncontrolled Port Authority marine fill operation occurring across the channel at the old U.S. Navy subbase piers. Only on two previous sampling occasions did fecal coliforms appear -- 11 per 100 ml on July 5, 1978, and 45 in November 1980. The cause for such isolated high counts is unclear. It appears from the available water quality data that sewage contamination from boats or other sources is not a matter of concern at this site. However, a popular sand swimming beach is at the bay head, in which area floatable waste would be unacceptable.

The extremely small undeveloped watershed of not more than 40 acres poses no immediate threat to the bay's water quality.

MANAGEMENT RECOMMENDATIONS:

- (i) Require Type I MSD's on all live-aboard boats.
- (ii) Implement effective soil erosion control to minimize potential sediment and nutrient input into the bay.
- (iii) Require holding tanks or locked heads on all the tourist-type commercial glassbottom, day tour or "head" boats which visit the bay.

plant should have an effluent BOD of about 40 mg/l. On the basis of the flow and effluent BOD, the total daily effluent BOD is 401 lbs./per day. The effluent is discharged into mangroves fringing the lagoon before emptying into the lagoon head water, and it can be expected that the mangroves in the discharge area remove some of the nutrients from the waste water. However, the amount must be very limited based on eutrophic water quality conditions in the lagoon head.

The Turpentine Run water course base flow information is not available at this time. However, based on visual observation, the author estimates the flow to be about 50 gallons per minute at a minimum (or about 72,000 gpd). The U.S. Geological Survey is presently monitoring the stream flow, and this information should be available in the near future. Based on the above estimate, a BOD loading of 54 lb./day must be added to the Nadir sewage plant loading, resulting in a total of 455 lb./day discharge into the lagoon head. The daily BOD load from all the live-aboard boats in Benner Bay and the North Shore section is 8.6 lb./day. The Lagoon Head receives 53 times more BOD loading from the sewage plants and base flow from the Turpentine Run water course or gut than Benner Bay receives from all the boats discharging sewage.

Sampling at station no. 27F at the False Entrance area, a remote anchoring spot for about 17 live-aboard boats, has consistently indicated good water quality, largely because the area experiences a high degree of water exchange through tidal currents and wave, swell and wind driven water over the open lagoon reef to the south. Access to the area is a channel about four to five feet deep (which is unmarked), and most of the surrounding shallow water is underlain by marine grass beds which suffer some periodic damage from outboard engine propeller impacts.

Shallow water depth is also of consequence in other parts of the lagoon, particularly on the edges of the heavily used coastal strip water way along the north shore and in the approaches to Benner Bay and Compass Point. Various dredging schemes have been suggested over the past decade to deepen channels and create new anchorage areas in the lagoon. Meanwhile; the practice of informal and illegal "blow out" or the use of propeller wash from power boats to deepen certain areas is common and was observed during the present survey effort. This is done to wash or "jet" away loose bottom sediments to create sufficient depth for boats in shallow dock areas. This action resuspends and distributes bottom sediments causing high turbidity levels, burial of other benthic organisms and probably increased oxygen demand of the resuspended organic matter. Evidence

of this practice of "blow out" was also observed in other areas and is likely a very frequent occurrence. It is, in effect, a mini-dredging operation and is, as noted, illegal.

MANAGEMENT RECOMMENDATIONS - GENERAL:

As noted above, the Mangrove Lagoon, for management purposes, needs to be segmented due to some of the concentrated pollution sources; however, a few generalized recommendations apply.

- (i) The near shore land based commercial facilities and homes should be sewerred if a more detailed investigation determines that the pollution contribution from these sources and their septic tanks is significant. Such action, however, must be accompanied by removal of the treatment plant effluent from the lagoon and by a monitoring program for the public dump leachates at the Lagoon Head.
- (ii) Effective soil erosion control must be instituted over all the watersheds draining into the lagoon.

The more specific recommendations are as follows:

MANAGEMENT RECOMMENDATIONS - BENNER BAY:

- (i) Sewage discharges from all boats, including live-aboards, should be prohibited.
- (ii) Identification and elimination of other significant pollution sources (probably from sewage effluent from major facilities directly fronting the shore) should be carried out.
- (iii) Mangroves on any shoreline where feasible should be revegetated.

MANAGEMENT RECOMMENDATIONS - NORTH SHORE:

- (i) Shore based pollution sources should be identified and terminated; the numerous smaller inputs may have a significant cumulative impact. A possible solution for at least residential structures and small commercial users is to encourage the use of composting toilets which have been

installed at a few locations, principally on St. John. Such toilets, while producing no effluent or at least a very minor amount for heavy usage, also have the major benefit of not requiring water for flushing. Alternatively, the entire littoral area should be sewerred.

- (ii) The protection of shoreline mangroves should be vigorously pursued as they absorb nutrients and stabilize the shoreline, in addition to providing other benefits to the lagoon environment.

MANAGEMENT RECOMMENDATIONS - LAGOON HEAD:

- (i) The most significant pollution source is the sewage outfall from the Nadir Sewage plant and Turpentine Run sewage base flow. These sources need to be removed from the lagoon watershed if any meaningful improvement in water quality and the marine ecosystem is expected.
- (ii) Leachate from the sanitary landfill should be further investigated to determine the degree of impact.

6. COWPET BAY.

The anchorage encloses an area of about 49 acres and contains at least 58 boats of which 51 are at moorings (29). The St. Thomas Yacht Club is located at the bay controlling most of the moorings. Live aboards are not allowed. A beach separated by a rocky promontory is heavily utilized by area residents. One water quality monitoring station is located in the bay (#24) (4). Only one environmental study has been made at this location (by Sigma Environments in 1978) which has been summarized by DCCA/DNRM (25) and is quoted here in full:

Cowpet Bay is a well protected, partly closed bay with a small watershed and recent environmental problems in water quality. Although water quality has previously been good, it is obviously declining. An Environmental Assessment Report by Sigma Environments in 1970 (*editor's note, should read 1978*) recorded that the benthic communities are diverse with Thalassia and Syringodium beds inshore, Halophila beds offshore and viable coral reefs on the southern end.

Due to [extensive] development within the small watershed and the practice of [using] treated sewage [effluents] for [landscaping] irrigation, an obvious accumulation of nutrients in the bay occurs continually. [This results] in periodic plankton blooms which are most noticable in the western portion of the bay. There is also a noted build-up of submerged macroscopic algae in the western portion. Currents are slow in the bay.

The above report also links sewage effluent from the condominiums' package plants and use for irrigation purposes to nutrient build-up in the bay.

Cowpet sewage plant has a design capacity of 75,000 gallons per day (gpd); with effluent reuse, however, the actual discharge is much lower, probably between 5,000 to 10,000 gpd during peak use months of December through April, at which time the on-site reverse osmosis plant operates at 9,500 gpd (personal communication, Cowpet Bay West management).

Anchorage Condominiums, in the watershed, also probably contribute some nutrient load to the bay due to its proximity to the shoreline.

Studies on evapotranspiration (evaporation and transpiration by plants) and soil moisture in the Virgin Islands have shown that a soil moisture deficiency under natural conditions exists for most of the year (40). During the wetter parts of the year, primarily September and October, when natural soil moisture is high, nutrients would tend to be washed into the bay with rainfall runoff.

DCCA/DNRM water quality data from station no. 24 did not indicate any long term significant pollution sources. An occasional fecal coliform is present in samples, while turbidity mean values of 0.7 NTU in 1979 and 1.2 in 1980 are above the mean turbidity values found in exposed south shore bays (0.6 and 0.9 for the respective years).

On the basis of the interviews conducted at Cowpet Bay, no live-aboards were found. This finding is consistent with the St. Thomas Yacht Club's regulation of not permitting live-aboards on boats in Cowpet Bay by any of the Club's members. The Yacht Club controls nearly all the moorings located in the inner portion of the bay; thus,

sewage input from that area can be considered as extremely minimal, if any. Several boats are anchored in the more exposed outer portion of the bay, and live-aboards may be present. However, the exposure of the bay to oceanic swells and currents limits the popularity of the anchorage, and, given the distance to the beaches, an occasional live-aboard anchored vessel poses no pollution problem to inner Cowpet Bay.

As noted above, some water quality problems do occur, and nutrients washed from land into the bay are suspected as the cause of periodic algae blooms. The watershed draining into the bay is relatively small (59 acres), but since flushing action appears low, any adverse impacts on the bay should be avoided, and soil erosion control strategies for the watershed need high priority.

MANAGEMENT RECOMMENDATIONS:

- (i) Reinforce the Yacht Club's policy of no live-aboards with a no discharge requirement for any live-aboards in the inner Cowpet Bay area, due to the proximity of a highly used water recreation area.
- (ii) The practice of gray water sewage effluent disposal by irrigation and subsurface disposal should be investigated to assess nutrient inputs into partially enclosed bays like Cowpet, particularly in situations where the disposal area is close to the shoreline and disposal rates are significant.
- (iii) Effective soil erosion control in the Cowpet Bay watershed is necessary to limit nutrient and sediment input into the bay.

7. VESSUP/RED HOOK.

The Vessup/Red Hook (and Muller Bay) water area comprises 138 acres of which Vessup Bay, the area most crowded with boats, is 34 acres.

The north shore of Vessup Bay contains several minor docks (4), a major marina facility (American Yacht Harbor, formerly the Johnny Harms Lagoon Marina), and the public dock facility operated by the Virgin Islands Port Authority. In June 1970, 93 boats were counted (6), while in March 1983, 196 were counted with 120 at docks and 76 anchored.

The public dock is also the ferry and heavy cargo loading point serving principally St. John. The Virgin Islands National Park Service has a docking facility on the southern shore of Vessup Bay.

The study area contains two DCCA/DNRM water quality monitoring stations (no. 22B, 50 feet from the head of Vessup Bay, and no. 22A, off the ferry dock) (4). An increase in turbidity and fecal coliform has been measured from 1973 to 1980, indicating deteriorating water quality (5, 6). The inner portion of Vessup Bay has little benthic life with the western bay head approaching anaerobic conditions (6, 7).

Due to the bay geometry, flushing rates and pollution susceptibility of Vessup and Red Hook/Muller Bays are significantly different. Vessup Bay is shallow, elongated, and restricted, while the latter is much deeper and open to the sea (7, 11). While current velocity information for Muller Bay is available (12), attempts to measure in Vessup Bay have not produced reliable results (13).

Other principal pollution sources, besides vessel waste discharges and septic tank waste leachates from American Yacht Harbor and other commercial and residential sites, include the Virgin Islands public sewage treatment plant at the western most shallow end of the bay and storm water runoff. The treatment plant with a design capacity of 125,000 gpd processes about 15,000 gpd domestic sewage primarily from the 1,200 pupil high school, the Red Hook Shopping Center, and part of the waste from American Yacht Harbor. The plant is designed for secondary treatment which would reduce BOD loading by eighty percent. Occasional faulty plant operation has resulted in periodic raw sewage flow into the bay with resulting high fecal coliform counts in the water quality sampling and odor problems in the area (6) (personal communication, R. Boulon, Director, Bureau of Fish and Wildlife, DCCA).

The land drainage into Vessup Bay is 542 acres (6) with a significant portion (167 acres) concentrated at the bay head (14). Heavy rainfall drainage into the bay in September and November of 1979 (Hurricanes David and Frederic) were apparently responsible for heavy nutrient loadings resulting in algae blooms (genus *Peridinium*). Algae blooms were also reported at the same time in the Mangrove Lagoon, Cowpet Bay and Water Bay (10).

The storm events resulted in measured precipitation for September (1979) of 13.75 inches at Ft. Mylner, 17.68 inches at Wintberg, and, during November 1979, 11.6 inches at Ft. Mylner (15). These rainfall intensities were, respectively, above the monthly averages by 250, 321, and 258 percent (16). While these were isolated storm events, it illustrates that heavy surface runoff from watersheds apparently results in significant nutrient inputs into coastal embayments. Nutrients and organic matter in surface runoff have been determined to be significant non-point sources of water pollution; however, further, site specific research is very much needed (30, 31, 32).

The Vessup Bay/Red Hook area, under the Virgin Islands Water Quality Standards, has been designated as Class "B" waters. This area, like the Mangrove Lagoon, should be separated into sub-units for management purposes, due to the significantly different parameters relating to water quality in the inner and outer bay.

A count of moored/anchored vessel distribution between the sheltered Vessup Bay and the more exposed Muller/Red Hook Bay showed 50 boats located in Vessup, of which 19 appeared to be live-aboards, with 26 vessels in the outer bay, of which 20 appeared to be live-aboards. All of the marine and docking facilities are located in the inner Vessup Bay area, with an additional 39 probable live-aboard boats.

The BOD contribution from the live-aboard boats in the inner Vessup Bay area is about 4.5 lbs./per day, while the loading in the outer Muller/Red Hook Bay area is 1.9 lbs./day. Further, it was found during the period from 24 February to 16 March, 1983, and perhaps longer, the sewage lift station for the Vessup Bay sewage plant was not operational. BOD samples taken by DCCA/DNRM on February 24, 1983, showed a value of 230 mg/l. For the 15 working days, i.e., not including Saturdays and Sundays, the total BOD load into the bay amounted to 435 pounds or about 29 lbs./day.

On a comparative basis, the daily sewage flow from the faulty pumping station contributed six times more BOD load than all the live-aboards moored, anchored or docked in Vessup Bay. This situation has been observed before and will undoubtedly reoccur.

During normal plant operations, assuming an effluent strength of 40 mg/l BOD, the daily loading is about 5 lbs./day BOD, which is about equal to that from boats. The inner bay, thus, receives at least 10 lbs./day BOD from these two principal sources, plus some minor contribution from the Port Authority's public toilet septic tank at the ferry dock and possible subsurface drainage from septic tanks on the north and south bay shores. Discussion with National Park Service personnel indicated that their toilet facilities receive very heavy usage from St. John passengers, taxi drivers, and others using the Park Service dock.

Other contributing pollution sources affecting the water quality of Vessup Bay and its aquatic environment include minor but frequent oil and fuel spills and bilge water discharges from the heavy boat activity (including the St. John ferries) at the Red Hook public dock, plus normal or accidental spillage of maintenance materials and chemicals and vessel propeller wash resulting in an almost continuous stirring up of bottom sediments.

Upon examination of the DCCA/DNRM water quality data for the two stations in Vessup Bay, no significant abnormalities appeared in the parameters for fecal coliform and turbidity, except for slightly higher turbidity values at station no. 22B at the bay head. (Table 10 shows the mean values for 1979 and 1980.) Both stations are well within the inner Vessup Bay area which is most seriously impacted by the various pollution sources. While the fecal coliform values do not exceed the Virgin Islands Water Quality Standards of 70 per 100 ml, except on a few sampling occasions (5/29/80 has >200 for station no. 22B), their continual presence indicates ongoing fresh sewage inputs into the bay; and the general stressed aquatic environment indicates pollution loading approaching or in excess of the bay's natural assimilative capacity. The bay shoreline and head have a narrow band of red mangroves and are heavily littered with trash, the accumulation of many years of littering and wind driven floatables from Pillsbury Sound.

MANAGEMENT RECOMMENDATIONS - VESSUP BAY:

- (i) Terminate the bay head sewage plant outfall. Previous recommendations have included land irrigation or a new ocean outfall eastward from Red Hook Point (7). All land based facilities around the bay should be connected to the sewer system once its outfall has been relocated. Any large volume new uses should not be permitted.
- (ii) All boat sewage discharges should be terminated.
- (iii) Control terrestrial soil erosion to minimize nutrient and sediment input into the bay.

MANAGEMENT RECOMMENDATIONS - RED HOOK/MULLER BAY:

- (i) Permit live-aboard boats only with Type I MSD's.

8. CRUZ BAY.

The only anchorage surveyed on St. John was Cruz Bay, the principal boat anchorage. St. John has numerous other anchorages frequented by boats in transit on cruises through Virgin Islands waters.

The bay is a well sheltered anchorage containing two areas, the "creek" and the main harbor, which encompass an area of 35 acres. The main harbor contains a public dock serving passenger ferries and a sand beach, while the "creek" serves more as a commercial area with all of the perimeter shoreline covered with a concrete bulkhead.

The town of Cruz Bay is situated in different watersheds above the bay. A boat count in January 1983 showed 22 boats in the "creek" and 53 in the main harbor, both moored and docked and including ferries and sixteen small boats on shore.

Two DCCA/DNRM water quality monitoring stations are located each in the "creek" and main harbor area (4). All measured parameters vary within narrow limits, with fecal coliform present at all stations at low densities about half the time. At the "creek" head, fecal coliform are present most of the time, probably resulting from septic tank effluent drainage in proximity to the shoreline (5).

The overall bay marine environment ranges from very poor in the "creek" to reasonably good in the seaward portion of the main harbor. A detailed study of the bay was completed by Brody, et. al. in 1969 (21), with an update by Grigg, et. al. in 1978 (22).

The bottom sediments vary from soft, dark upland mud and organic debris in the "creek" to clean carbonate sand with shell fragments in the shallow parts of the outer bay; most of the main bay contains a bottom of fine silty to coarse sand. A coral reef extends across much of the bay entrance. Three large areas of sea grass occur in the bay. Four major benthic groups include coral, sea grass, green algae and worms. Few large invertebrates occur, but worms and burrowing molluscs are abundant (22).

The bay faces west and is sheltered from the prevailing easterly winds and the north equatorial current. Tides and wind are believed to be the principal driving forces for bay water exchange, although currents in the bay are weak, with almost no circulation in the "creek" itself (22). Cruz Bay is considered a partially closed bay with a high pollution susceptibility (11).

Pollution of the bay results from three principal sources: 1) surface runoff which, with increasing watershed development, will be increasingly dominant; 2) sewage from boats; and 3) septic tank drainage.

Although a 20,000 gpd. sewage plant is located at Enighed Pond outside of the Cruz Bay watershed, few connections to the system have been made in the town/watershed of Cruz Bay (personal communication with Pedrito Francois, Department of Public Works). Prop-wash from ferries and anchor chain movement from boats continue to physically disturb the bay bottom. Oil spills and oily bilge water and other pollutant inputs exist, but no quantification of these sources is available or was possible.

The Cruz Bay harbor, like some of the other anchorages, is exhibiting sufficient spatial gradation in its aquatic environmental quality parameters to warrant different management strategies for its two main areas, the "creek" and the main harbor, which are separated by a point of land. Further, the harbor area is somewhat unique because of its sandy recreational beach, in immediate proximity to the boat activity area (ferry dock) and vessel anchorage/mooring area.

As noted above, both areas experienced frequent low level fecal coliform counts in the water sampling, with the exception of the sampling of the creek head (station no. 43C) which, on two sampling occasions (5/17/79 and 4/23/80), exceeded 200 fecal coliform per 100 ml. The Virgin Islands Water Quality Standards for class "B" water is a maximum of 70 fecal coliform per 100 ml. It is very likely that these limits have been exceeded more frequently as the sampling occurred no more frequently than once a month.

On the two above referenced dates, substantial rainfall was recorded in Cruz Bay which received 1.34 inches on May 16 and 0.57 inches on May 17, 1979, while April 23, 1980, recorded precipitation at 0.86 inches. This suggests a connection between storm runoff and sewage pollution of the harbor. However, a more extensive correlation between these two variables needs to be established before a more definite conclusion can be reached.

The lower level but chronic fecal coliform counts in the harbor area does suggest pollution sources from live-aboard boats and other possible sources as most of the houses in the town have not yet been connected to the sewage plant and are using septic tanks. The BOD input from the occupied boats in the harbor is 810 lbs./year, all from vessels moored or anchored. There were no live-aboards found at any docked locations.

It should be noted that for a number of years the Virgin Islands Port Authority has been considering the development of the Enighed Pond area, to the south of Cruz Bay, as a commercial small boat marina. A number of problems, principally of an institutional and financial nature, have presented its realization (personal communication, Jack Monsanto, Virgin Islands Port Authority). The heavy marine traffic, the saturation of Cruz Bay harbor with anchored boats, and the general congestion there have resulted in the degradation of the bay's water quality and have adversely impacted the recreational usefulness of Cruz Bay beach (from a resource management stand point, the recreational value of the beach is very high due to its proximity to the town). Thus, the Enighed Pond "diversion of activity" strategy is an environmentally attractive alternative.

MANAGEMENT RECOMMENDATIONS:

- (i) Sewage discharge from boats needs to be eliminated due to the low flushing capability of the bay and the proximity of the beach.
- (ii) The discharge of all other pollutants, including oil (and oily bilge water), cleaning fluids and chemicals, and trash (including bottles and cans) needs to be eliminated.
- (iii) Terrestrial sewage pollution sources need to be identified and eliminated by connection to the sewage system.
- (iv) The Cruz Bay/Enighed Pond development plan for the construction of a commercial marina (and other revenue producing marine related facilities) should be reactivated, in order that the heavy usage of the harbor is shifted to the pond.

Table 10. DCCA/DNRM Water Quality Data (Yearly Mean).

△ indicates location of DNRM Water Quality Stations on Figures 5 through 11.

CHRISTIANSTED STATIONS

		#40	#41	#42	#43	#44
1980	Turbidity	1.6	2.5	1.8	2.1	1.0
	Fec. Col.	41	35	118	231	1
1981	Turbidity	1.9	2.2	2.1	2.2	1.5
	Fec. Col.	30	42	208	15	2

TAGUE BAY STATIONS

		#8	#9
1980	Turbidity	1.6	1.7
	Fec. Col.	3	2
1981	Turbidity	1.5	3
	Fec. Col.	3	20

CHARLOTTE AMALIE HARBOR STATIONS

		#31A	#31C	#32A	#32B	#33	#34	#35	#36	#37	#38
1979	Turbidity	0.7	1.1	1.6	1.7	2.2	1.2	1.5	2.0	1.1	0.8
	Fec. Col.	Neg.	4	89	550	429	21	24	278	56	5

MANGROVE LAGOON STATIONS

		#26A	#26B	#27A	#27B	#27C	#27D	#27E	#27F	Exposed Bays South Coast
1972-78	Turbidity	2.3	-	3.2	3.4	-	-	-	-	0.6
	Fec. Col.	15	-	64	24	-	-	-	-	0.5
1979	Turbidity	2.5	3.1	6.0	5.2	3.9	1.9	1.3	0.9	0.6
	Fec. Col.	40	32	593	81	20	26	24	0.6	2.3
1980*	Turbidity	2.5	2.9	6.1	5.0	2.8	2.8	1.0	0.8	0.9
	Fec. Col.	41	14	80	27	16	1.7	25	2	1 (Feb.-Aug.)

* 1 January to 31 August

COWPET BAY STATION

		#24
1979	Turbidity	0.7
	Fec. Col.	1.2
1980	Turbidity	1.2
	Fec. Col.	0.1

Table continued →

Table 10 (cont'd.). DCCA/DNRM Water Quality Data (Yearly Mean).

VESSUP/RED HOOK STATIONS					
		#22A	#22B		
1979	Turbidity	1.1	2.1		
	Fec. Col.	10	10		
1980	Turbidity	1.3	1.4		
	Fec. Col.	3.6	23		

CRUZ BAY STATIONS					
		#43A	#43B	#43C	#43D
1979	Turbidity	1.2	1.1	2.2	1.6
	Fec. Col.	10	2.7	24	0.2
1980	Turbidity	1.3	1.4	2.6	2.3
	Fec. Col.	7.8	6.3	24	14

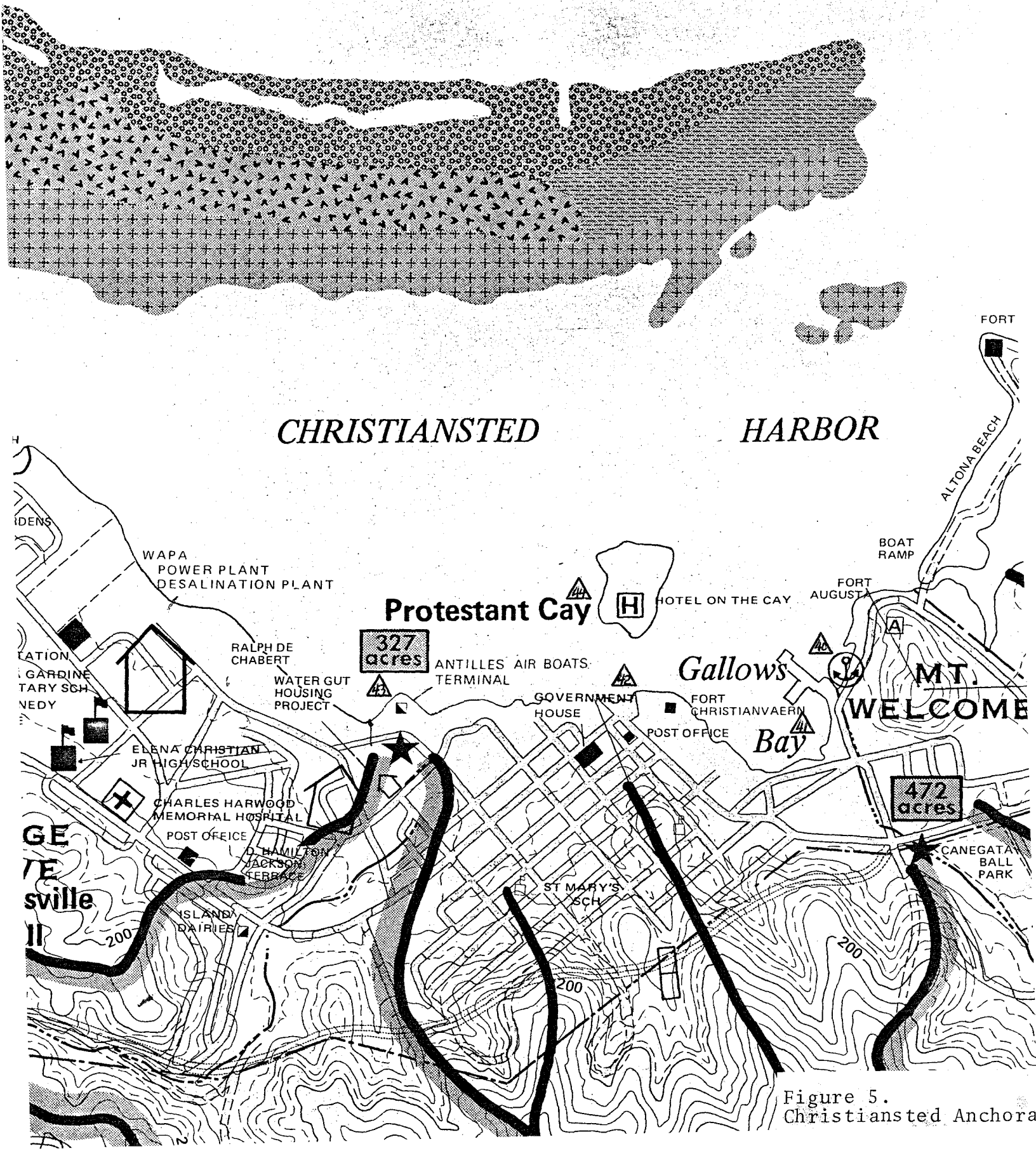


Figure 5.
Christiansted Anchorage

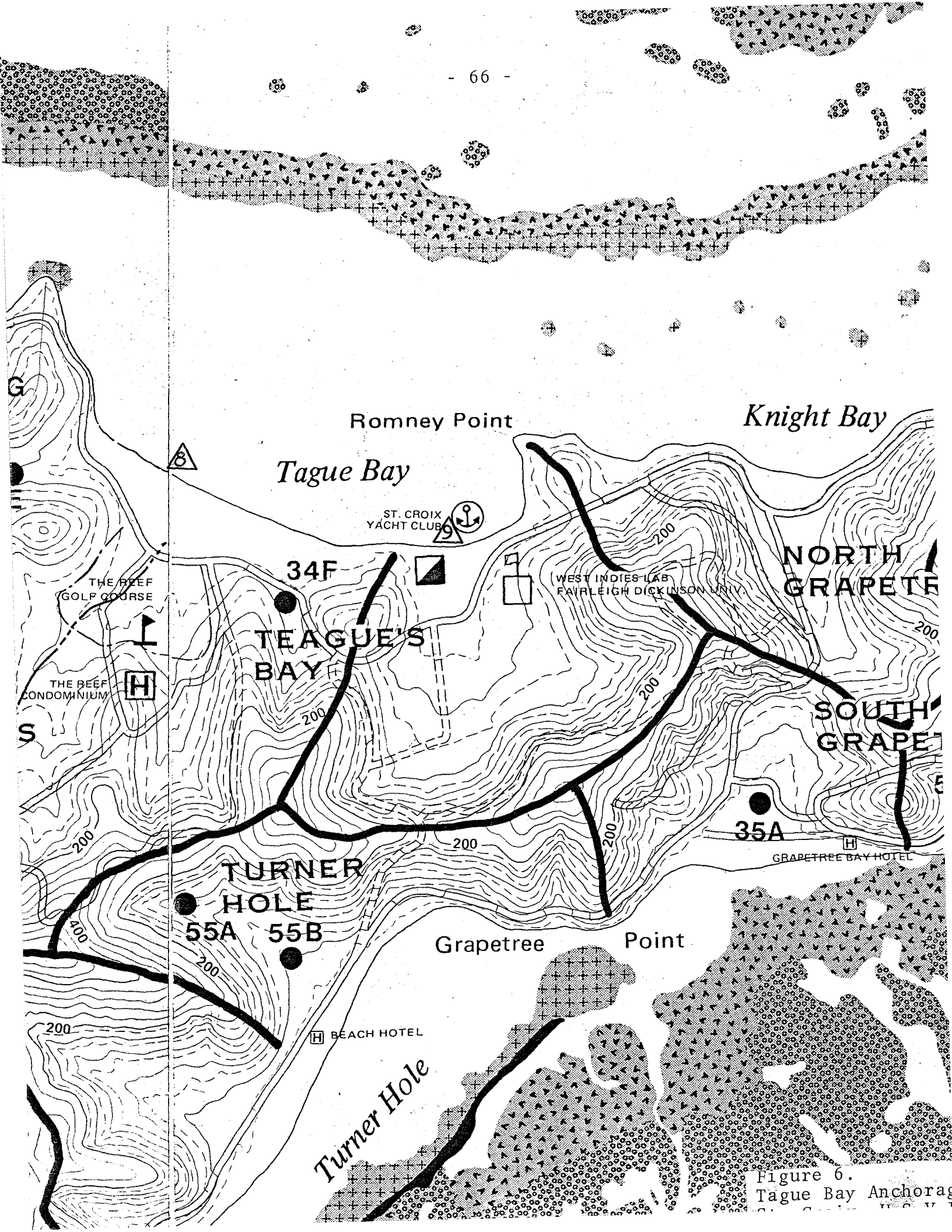


Figure 6.
Tague Bay Anchorage

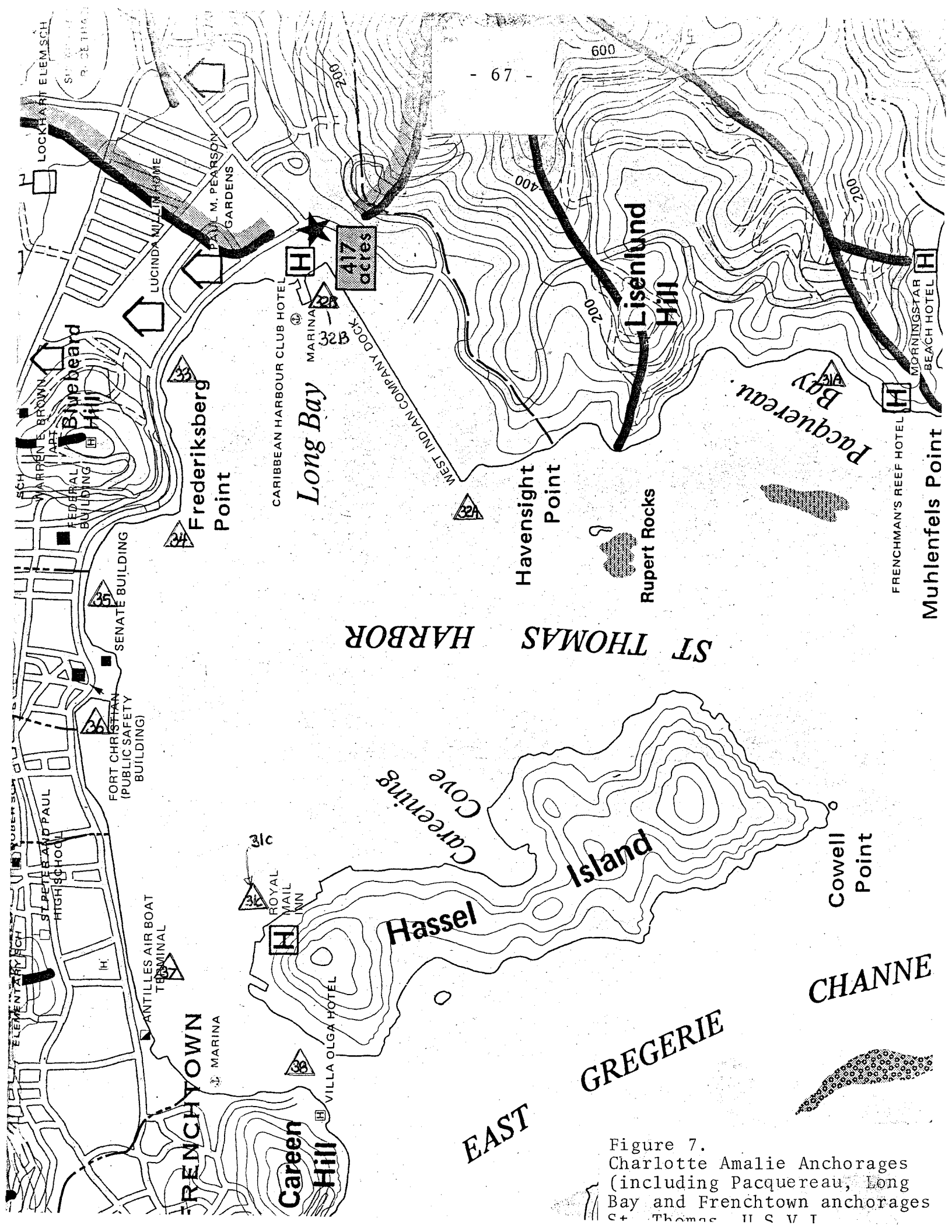


Figure 7.
Charlotte Amalie Anchorages
(including Pacquereau, Long
Bay and Frenchtown anchorages
St. Thomas, U.S.V.I.)

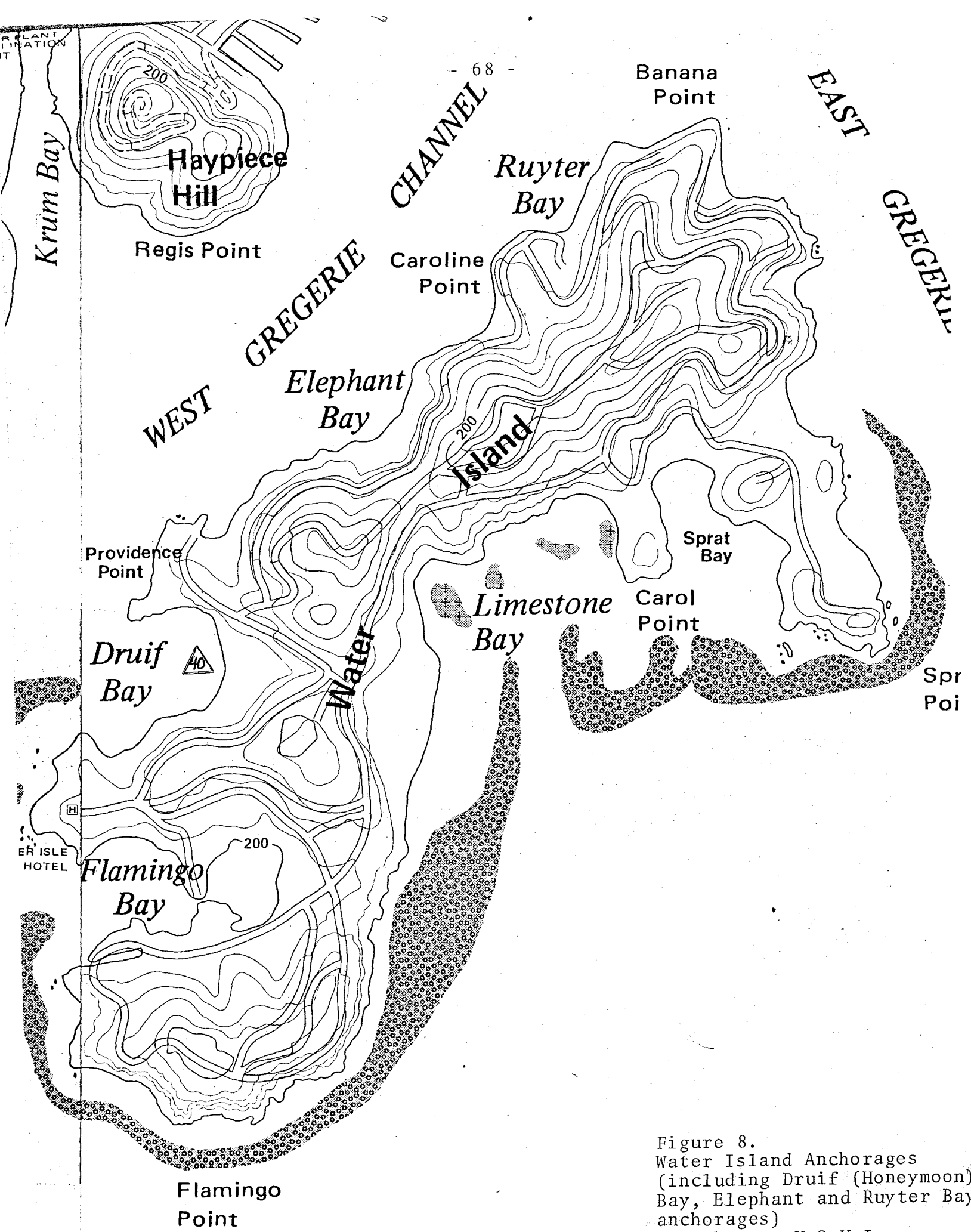


Figure 8.
 Water Island Anchorages
 (including Druif (Honeymoon)
 Bay, Elephant and Ruyter Bay
 anchorages)
 St. Thomas, U.S.V.I.

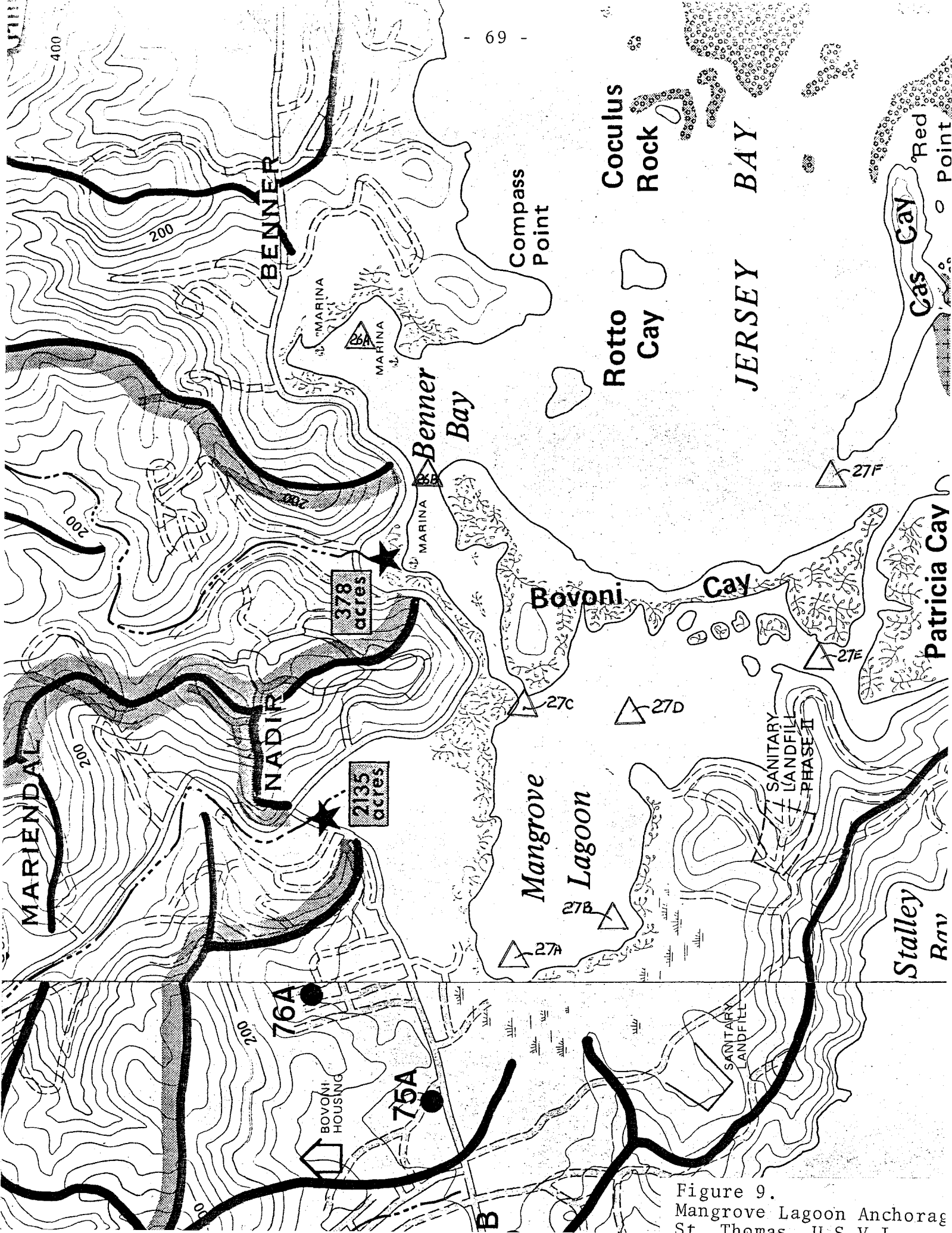


Figure 9.
Mangrove Lagoon Anchorage
St. Thomas, U.S.V.I.

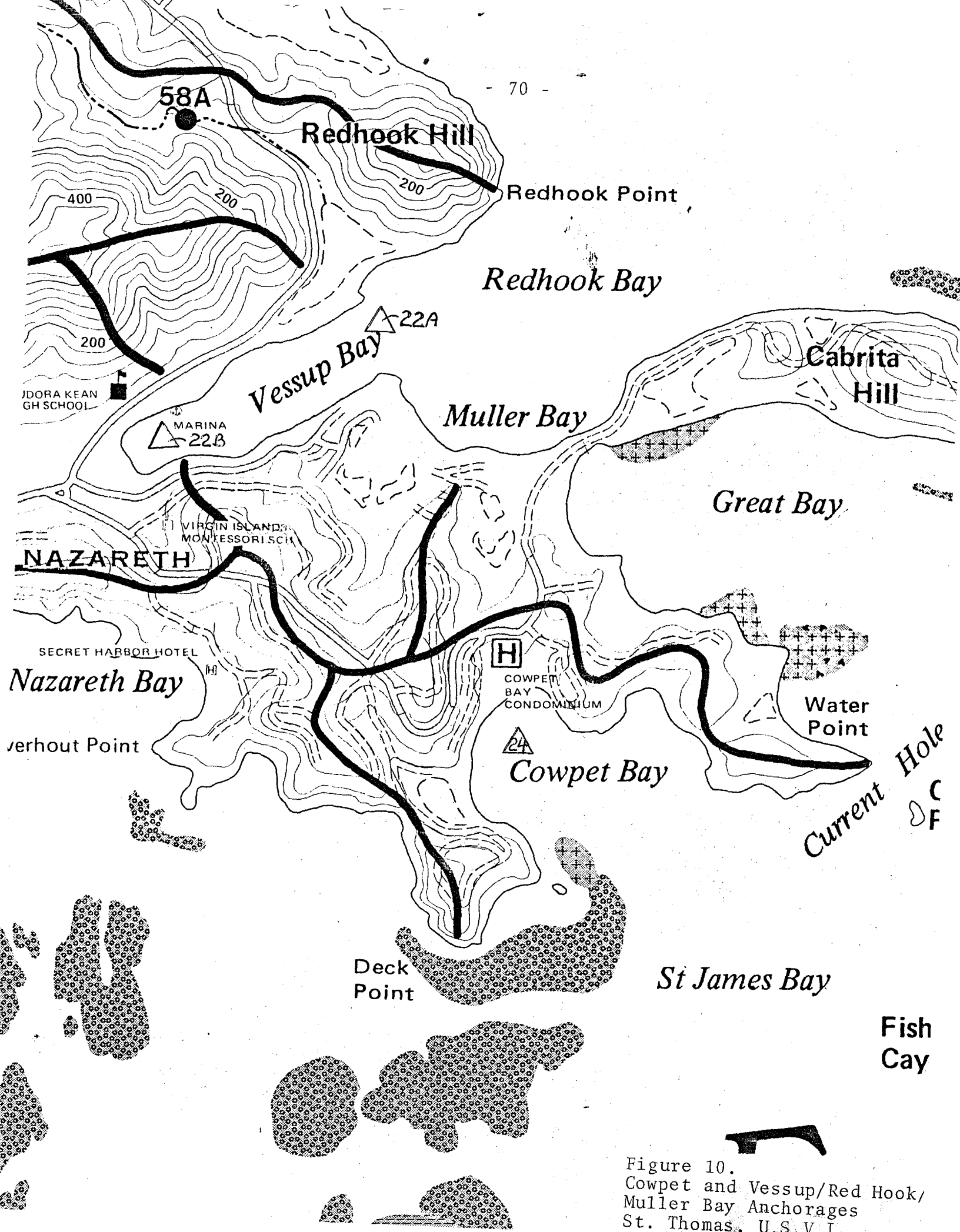


Figure 10.
Cowpet and Vessup/Red Hook/
Muller Bay Anchorages
St. Thomas, U.S.V.I.

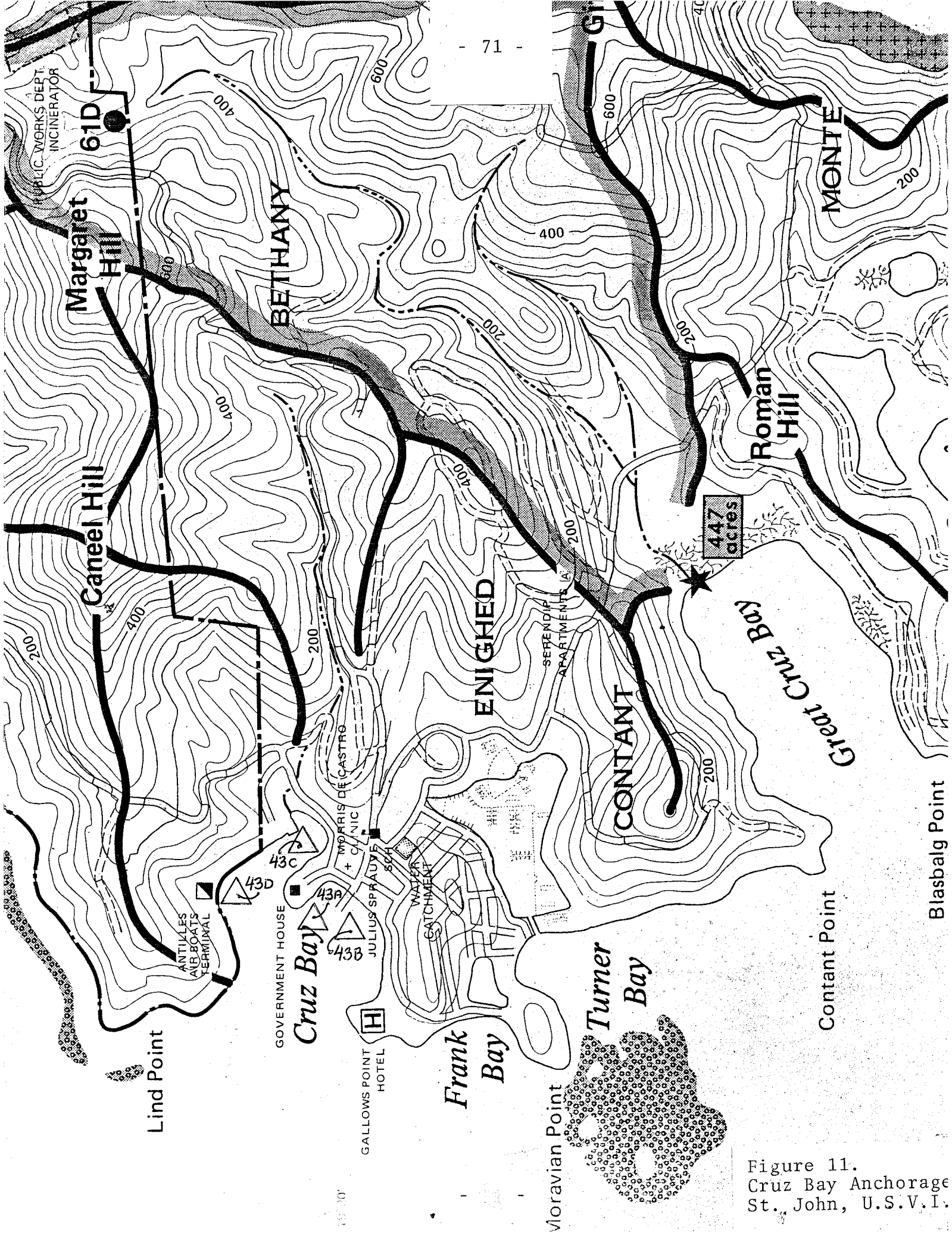


Figure 11.
Cruz Bay Anchorage
St. John, U.S.V.I.

VII. ANALYSIS OF EXTANT LEGISLATION AND PROGRAMS.

The prohibition and/or monitoring of pollution discharges into the Virgin Islands territorial waters is directly and indirectly addressed by seven separate federal and Virgin Islands laws. Title, legal reference and administrative agency are briefly summarized below, followed by a more detailed description.

TITLE/CODE CITATION	IMPLEMENTING AGENCY	AREA OF JURISDICTION
Water Pollution Control Act (12 V.I.C., Sect. 181, <u>et.seq.</u>)	Virgin Islands Dept. of Conservation and Cultural Affairs (DCCA)	All territorial waters
Oil Spill Prevention and Pollution Control (12 V.I.C., Sect. 701, <u>et.seq.</u>)	DCCA V.I. Port Authority	All territorial waters
Coastal Zone Management Act (12 V.I.C., Sect. 901, <u>et.seq.</u>)	DCCA	All territorial waters
Solid and Hazardous Waste Management (19 V.I.C., Sect. 1551, <u>et.seq.</u>)	DCCA Dept. of Public Works Dept. of Health Dept. of Public Safety V.I. Port Authority	Shorelines and territorial sub- merged lands and waters
Commercial Fishing (12 V.I.C., Sect. 301, <u>et.seq.</u>)	DCCA	all territorial waters
Port Authority Act (29 V.I.C., Sect. 54 and 25 V.I.C., Sect. 131, <u>et.seq.</u>)	V.I. Port Authority	Harbors
Clean Water Act (Federal Water Pollution Control Act, as amended) (33 U.S.C., Sect. 466, <u>et.seq.</u>)	U.S. Coast Guard (for Marine Sanitation Device Regulations)	All territorial waters

TABLE 11. Legislation Prohibiting and/or Monitoring Pollution Discharges in the Virgin Islands.

A. Virgin Islands Code.

1. WATER POLLUTION CONTROL ACT.

The enabling legislation empowers DCCA to manage all territorial water and to prevent water pollution. "Vessels or other floating craft" are included as pollution point sources.

Any point source pollution discharge is only permitted upon the issuance of a permit. However, according to the Rules and Regulations, sewage and other discharges incidental to the normal operations of a vessel are exempted from the permit requirement.

Water Quality Standards for territorial coastal waters are set forth under 12 Virgin Islands Rules and Regulations 186-1 et seq. Three classes have been established: "A", "B" and "C" with corresponding criteria. Class "A" includes waters of pristine natural condition which are not to be degraded; Class "B" are other waters than those of Class "A" or Class "C"; and Class "C" waters are principally the harbor or industrial areas, specifically defined as follows. (Appendix D shows the Water Quality Standards):

(1) St. Thomas:

- (A) St. Thomas Harbor beginning at Rupert Rock and extending to Haulover Cut.
- (B) Crown Bay enclosed by a line from Hassel Island at Haulover Cut to Regis Point at West Gregorie Channel.
- (C) Krum Bay.

(2) St. Croix:

- (A) Christiansted Harbor from Fort Louise Augusta to Golden Rock.
- (B) Frederiksted Harbor from La Grange to Fisher Street.
- (C) Hess Oil Virgin Islands Harbor.
- (D) Martin-Marietta Alumina Harbor.

2. OIL SPILL PREVENTION AND POLLUTION CONTROL.

This legislation prohibits the discharge of oil, other petroleum products or other pollutants upon any coastal waters of the territory.

Vessels of any type are covered under the act, as well as other pollution sources. Pollutants are defined as, but not limited to, oil, gasoline, pesticides, ammonia chlorine and other hazardous materials; while pollution which interferes with the enjoyment of life or property, including outdoor recreation, is also prohibited.

Any illegal discharge must be reported to the Harbor Master and nearest U.S. Coast Guard station. The Harbor Master shall notify the Department of Conservation and Cultural Affairs about the pollution event. The DCCA is responsible for effecting the removal of the pollutant, either by having the polluter clean up the spill or by use of its own resources.

In order for DCCA to remove a spill, the act establishes a coastal protection fund, which may be used for training and for pollution control equipment procurement. Failure to report a spill may result in a civil penalty up to \$50,000. for each day of the violation. The Act gives responsibility to the Virgin Islands Port Authority for the removal of sunken vessels or wrecks.

3. COASTAL ZONE MANAGEMENT ACT.

The act empowers the DCCA to regulate (in the coastal zone) land/water development, including marinas, boat related facilities and boat mooring areas. Any development or construction can only take place after a permit is issued either by the Commissioner or the Coastal Zone Management Committee or Commission. In the event of proposed development on or in water (submerged land), a permit from the U.S. Army Corps of Engineers is also required.

The CZM Commission is empowered to recommend areas of particular concern (APC's) to the Legislature for adoption. The goals of the act include the protection of significant ecological resource areas such as reefs, marine meadows, salt ponds, mangroves and other significant natural areas, as well as the maintenance or improvement of coastal water quality through erosion sedimentation, run-off, siltation and sewage discharge control.

Section 909. Areas of particular concern.

The [Coastal Zone Management] Commission may recommend, after reasonable notice and public hearings, designation of areas of particular concern within the first tier of the coastal zone and submit such recommendations to the Legislature for adoption. In recommending the designation of areas of particular concern, criteria for selection and implementing action shall be included in a report prepared and adopted by the Commission.

Violators of the act are subject to a civil fine of up to \$10,000./day with additional fines or imprisonment for willful violations.

4. SOLID AND HAZARDOUS WASTE MANAGEMENT.

The act interfaces with boat use in three areas: 1) Section 1555 requires that all business and commercial establishments provide for the collection and transportation to an approved disposal site of all generated wastes. This provision includes marinas and would definitely include garbage generated on boats and possibly waste oil. The latter, however, is not specifically covered in the act. 2) Section 1559 provides for the removal of any abandoned or wrecked boats from the shoreline or submerged lands by the Virgin Islands Port Authority. 3) Section 1563.13 prohibits the disposal of any waste into a body of water except as may be specifically allowed in other pertinent sections of the Virgin Islands Code.

Under the definition of the act, coastal waters, wharves, docks, and piers are included.

Violations of the act may result in a \$250. maximum fine and/or 60 days imprisonment.

5. VIRGIN ISLANDS PORT AUTHORITY.

The Rules and Regulations effective under Title 25 prohibit the dumping of refuse or discharge of fuel oil into the harbor waters; however, sewage is not included. Houseboats, defined as boats built for residential use and not built for transportation, are prohibited from anchoring or mooring in the harbors of Christiansted, Frederiksted, Charlotte Amalie, Vessup Bay, Coral Bay and Cruz Bay.

Act 4205, an amendment to Title 29, grants police powers to the Marine Division of the Authority to enhance the field personnel's capability in enforcing the Rules and Regulations. However, the act also mandates that the Authority submit a training program to the Legislature for approval for those personnel who would exercise such police power (including the carrying of weapons). Such a training program was not submitted, and the act failed in its purpose.

Currently, proposed Rules and Regulations under Title 29 have been drafted but are not in effect. Sewage, garbage oil, gasoline, etc. are prohibited from being discharged into harbor waters. However, it is not clear how the prohibition against sewage discharges would be enforced (locking of heads?). This prohibition would apply only to small craft less than 100 tons, but not to larger vessels, e.g., cruise ships.

6. COMMERCIAL FISHING.

This legislation prohibits the contamination of fishing waters (section 323). Conservation officers from DCCA are authorized to act as police officers, to be armed and to make arrests for violation of conservation laws. Contamination of fishing waters is punishable by a fine of \$300. for each offense and/or six months imprisonment. No one has ever been charged or convicted.

B. United States Code.

The Clean Water Act (formerly the Water Pollution Control Act) addresses sewage disposal directly. The act, as amended, provides for the Administrator of the U.S. Environmental Protection Agency, in consultation with the Secretary of the U.S. Department of Transportation, to promulgate federal standards for the performance of marine sanitation devices. The Marine Sanitation Device Regulations, 33 CFR 159, were published on January 30, 1975. The final compliance deadline for existing vessels was January 30, 1980, while new vessels sold after January 30, 1977, should have been built in compliance with the regulations. The regulations provided for three types of sanitation devices on vessels which contain toilets: Type I, II, and III.

Type I. No floating solids, not more than 1,000 fecal coliforms per 100 ml.

Type II. Maximum allowable 150 mg/l suspended solids, and not more than 200 fecal coliform per 100 ml.

Type III. Holding Tank.

All vessels over 65 feet in length must either have Type II or III devices. Exceptions to compliance with the regulations are made on an individual, case by case basis.

The U.S. Coast Guard is the designated enforcement agency. Compliance with the regulations is made through boarding inspections, although not for the sole purpose of determining compliance with the Marine Sanitation Device Regulations, except when an obvious violation exists. In cases of violation, the case will be reported -- in the Virgin Islands to the Seventh Coast Guard District in Miami -- and a district hearing officer will consider the case for assessment of a civil penalty. This penalty may be as high as \$2,000. for a vessel owner. Non-compliance with the determination of the district hearing officer is referred to the District Court of the Virgin Islands.

The act further provides for the Coast Guard to enter into agreements with other federal or state (territorial) agencies for the enforcement of the Marine Sanitation Device Regulations. In the Virgin Islands, the appropriate agencies would be the DCCA/Bureau of Enforcement and the Port Authority, although such agreements have not been entered into.

C. Existing (Draft) Regulations/Management Plans.

In the past several years, various efforts have been initiated locally to develop management strategies and plans for coastal areas, all of which, to date, remain in proposed or draft form. These include:

1. Harbor and Coastal Water Use Plan, by the Department of Conservation and Cultural Affairs.
2. Port Authority Small Craft Mooring Proposal.
3. Port Authority Rules and Regulations, pursuant to Title 29.
4. APC Plan for Vessup/Muller/Red Hook Bay Complex, St. Thomas, by the Department of Conservation and Cultural Affairs.
5. APC Plan for the Mangrove Lagoon, St. Thomas, by Department of Conservation and Cultural Affairs.
6. The St. Thomas National Marine Sanctuary and Draft Environmental Impact Statement.

A synopsis of each of the above is provided with emphasis on vessel waste disposal. However, no attempt has been made to provide a critical review of the total thrust, practicality, or quality of these documents, but merely to note their existence since they could become the basis of future legislation, interagency agreements, or legalized administrative procedures and management strategies for the Territory.

1. HARBOR AND COASTAL WATER USE PLAN FOR THE U.S. VIRGIN ISLANDS (Discussion Draft), August 26, 1980.

This plan provides for guidelines and implementation mechanisms to manage some of the varied demands placed upon coastal waters by human activities. A summary of the report is available and has been included in Appendix G. A companion document, entitled Environmental Information Relevant to the Installation of Boat Moorings in the Coastal Waters of the U.S. Virgin Islands (DCCA, June 1981), was apparently prepared to serve as the environmental impact assessment report (required under the V.I. Coastal Zone Management Act) for DCCA to obtain from the V.I. Coastal Zone Management Commission a general permit for the designation of the mooring/anchorage areas. It maps

the proposed mooring areas and provides for a schedule of mooring fees to be paid to DCCA.

The environmental impact of boats is generally discussed, and a brief description of water quality in each of the selected mooring areas, which are the same as those investigated in the current vessel waste disposal study, is provided. Also, addressed are the impacts on public services such as sewage treatment if boats were permitted to discharge into the public system, solid waste disposal, auto traffic and parking, and social and economic impacts.

2. V.I. PORT AUTHORITY/COASTAL ZONE MANAGEMENT - DESIGNATING SMALL CRAFT MOORING AREAS IN U.S. VIRGIN ISLANDS WATERS (1981).

This draft document was the centerpiece for public hearings held on the three islands in October 1981. It had two primary points:

- (1) the designation of the mooring areas in harbors under Port Authority jurisdiction; and
- (2) a schedule of mooring fees.

The proposed plan would serve as a sub-permit of the general permit of DCCA. Environmental or health issues related to water quality were not addressed in this plan. The mooring areas in the harbors are the same as those proposed in the DCCA general permit application.

3. V.I. PORT AUTHORITY RULES AND REGULATIONS PROMULGATED UNDER TITLE 29.

Sewage, garbage, oil, gasoline, etc. are prohibited from being discharged into harbor waters. However, it is not clear how the prohibition against sewage discharges would be enforced. The prohibition would apply only to small craft less than 100 tons, but not to larger vessels (see also below, Section D).

4. STATUS REPORT AND MANAGEMENT RECOMMENDATIONS FOR THE VESSUP/MULLER/RED HOOK BAY COMPLEX/AREA OF PARTICULAR CONCERN (APC). DRAFT PLAN, July 1981. Prepared by Coastal Zone Management Division of DCCA.

The plan describes the physical characteristics of the bay complex and its watershed. Fauna and flora of the land are identified as well as tides, currents, water quality, and

the marine resources of the bay complex. The rapid increase in boating activity is documented, as well as accelerating land-based development. Such rapidly increasing activities have resulted in use conflicts in the overall area and substantial degradation in the water quality and marine ecosystem of Vessup Bay. Management strategies are recommended for existing and future land and water uses including, among others, the designation of swimming areas, permanent and temporary boat anchorages/moorings and the removal of sewage treatment plant effluent discharge from the head of Vessup Bay. The matter of boat sewage discharges is discussed, and a form of sewage treatment or removal of sewage from boats in Vessup Bay is deemed desirable due to nutrient build-up. Dredging the head of Vessup Bay is also recommended. The report's Table of Contents is found in Appendix E.

5. A MANAGEMENT PLAN FOR THE ST. THOMAS MANGROVE LAGOON
AREA OF PARTICULAR CONCERN (APC). DRAFT PLAN, 1981.
Prepared by the Coastal Zone Management Division of DCCA.

The proposed plan considers the Mangrove Lagoon and the Turpentine Run/Tutu Watershed as a management unit. The current major pollutant sources are identified with recommended solutions for their abatement or elimination. Included are the sewage treatment plants, sanitary landfill leachates, sediment transport from the watershed, copper and toxic substances from boat repair facilities, and other smaller intrusions into the mangrove ecosystem.

Restoration of previously destroyed or damaged mangrove areas is called for as well as removal of illegal fill from wet lands. Included in the recommendations is the complete removal of the road/dike at the "Compass Point salt pond." This fill had, in fact, been partially removed several years ago under an agreement between the U.S. Army Corps of Engineers and the upland property owner, Mr. William Clarenbach.

Regulation of future land development in the APC watershed is called for based on the limitations imposed by natural features, such as land slopes and flood plains, and minimal disruption of sensitive ecological areas, such as reefs and wet lands.

The Table of Contents for this document is found in Appendix F.

6. THE ST. THOMAS NATIONAL MARINE SANCTUARY AND DRAFT ENVIRONMENTAL IMPACT STATEMENT (April 1981).

The abstract of the above referenced document is presented in full as follows:

The National Oceanic and Atmospheric Administration (NOAA) proposes the designation of the waters immediately off southeast St. Thomas, United States Virgin Islands, as a marine sanctuary. The proposed sanctuary consists of 9.27 square nautical miles of waters under territorial jurisdiction.

The designation of a marine sanctuary would establish a program of comprehensive management, including research, assessment, monitoring, resource interpretive programs, coordination and regulation. The preferred alternative includes sanctuary management goals and objectives which will serve as a framework around which sanctuary activities will be structured.

The Virgin Islands would promulgate specific regulations pursuant to the Virgin Islands Coastal Zone Management Act of 1978 (12 V.I.C., Sec. 901) which would apply only within the sanctuary boundary. NOAA will also adopt these regulations as its sanctuary regulations. The proposed regulations prohibit the taking or damaging of any living natural resource; permit traditional fishing methods except at designated dive areas; prohibit disturbance of cultural resources; prohibit anchoring in a manner /sic/ damaging to coral; prohibits the discharge of substances except cooling waters from vessels, fish, fish parts or chumming materials, and discharges from marine sanitation devices. In addition, the proposed regulations limit alteration of the seabed to the area outside of the Mangrove Lagoon and only allow such activities in the public interest.

Alternatives to the proposed action include the no action or status quo alternative, and modification of the sanctuary boundaries.

D. Conclusions and Recommendations Regarding Draft Regulations/Management Plans.

The above referenced proposals for legally enforceable management plans and associated or separate rules and regulations could and should be adopted pursuant to appropriate existing legislation. The fact that all these proposed legal instruments are in draft or preliminary form presents an opportunity to move ahead rapidly. It will, however, be necessary to eliminate implicit conflicts before final approval and implementation stages are reached.

The CZM/APC management plan approach should be expanded to include the other boating/bay/harbor/anchorage areas covered in this survey effort and possibly other coastal areas as adverse impacts and vessel concentrations expand. The APC mechanism provides a flexible tool to assess each individual site based on its limitations and potentials and to maximize and manage desirable areas. It also forces inter-agency liaison and a coordinated approach.

The two draft reports for the Vessup Bay/Muller/Red Hook Bay complex and the Mangrove Lagoon need to be updated with current information. The former plan is well organized, easy to read and comprehend with clearcut management guidelines presented; the latter could be improved in the same manner.

It should be stressed that the APC proposals are not meant to be reference documents to be filed in a library, but rather are working management guideline documents which will or should be scrutinized by groups and individuals with varying interests or backgrounds, and which will be subjected to public review and the political approval process.

The APC management plans should be to the point and well documented. It is further recommended that a format or guidelines be developed for the preparation of the APC studies in order that the plans which are prepared for each site are of consistent quality in terms of context, readability, effectiveness, etc.

All the proposed regulations or management plans must be consistent with one another to avoid future inter-agency conflict and to eliminate gaps and loopholes and provide for a coordinated approach to enforcement and pollution abatement in critical areas.

The V.I. Port Authority's small craft mooring proposal would prohibit sewage discharges in all harbors. Not only is such a requirement unrealistic in terms of enforcement, but it is also not defensible on either environmental or economic terms.

It has been established in the current study that all bays and harbors have their own unique characteristics and that the principal parameters related to boat sewage discharge are the flushing or dilution rate available in the bay and the various uses to which the harbor waters are subjected. For instance, the inner portions of Vessup Bay and Benner Bay experience extremely low flushing action and sewage discharge should be prohibited, while the more open and better flushed Red Hook/Muller Bay can tolerate boat sewage discharges. This is not to say that it is desirable. However, given the limited manpower, budget and equipment which the Port Authority has at its disposal, it would seem prudent that limited resources be employed where they are most needed, i.e., in those harbors where vessel sewage discharges are a significant problem.

The other and related issue is that of the specific manner in which such regulations can be enforced. To state that boats shall not discharge sewage may be a commendable policy goal, but how it will be enforced in the field is another issue. Not only is the detection of such discharge difficult, but the means or methods of proof need also be considered. The prosecution of small oil spill polluters, for example, has been almost impossible due to the necessity of finding an acceptable legal manner in which to document the violation.

Clearly, the control of waste discharge should be approached via a more practical performance and enforcement strategy. It is recommended that the Port Authority's Rules and Regulations be consistent with the APC plans of DCCA and vice versa, in the same manner in which the two agencies have joined their efforts in developing the proposed mooring plans with shared, carefully delineated responsibilities.

The DCCA Harbor and Coastal Water Use Plan should be considered a component of the APC management plans developed for the various harbors and bays. The APC approach is currently the only comprehensive management tool available which takes (or has the potential to take) into consideration all of the adverse or beneficial actions occurring in a harbor or bay. It further takes into account the land-based impacts by including the watershed as part of the study area. Only by such a comprehensive approach can the serious management problems existing at the many bays and harbors of the Virgin Islands be resolved. Boat sewage is only a part of the environmental quality issues which need to be addressed relative to coastal waters, and is, in some cases, only a small proportion compared to land-based pollution loading.

The commercial harbors of the Virgin Islands experience appreciable cruise ship and other commercial, large vessel traffic. Eight hundred fifty-eight cruise ships visited Virgin Islands ports in 1981 (U.S. Virgin Islands Growth Statistics, V.I. Department of Commerce). Most of these vessels dock or anchor in the major commercial harbors, with thousands of passengers aboard. No Virgin Islands law prohibits the discharge of sewage while such vessels are in port, and the proposed Port Authority Rules and Regulations, while proposing the prohibition of sewage discharge from small craft, are silent on similar discharges from large vessels. It is recommended that large vessels not be exempted from any vessel sewage management plans.

It should be noted that any effort at resource management should fully involve the resource users and groups affected to the greatest extent. In this case, the boating public, through their various organizations, should be called upon to provide input to any proposed management plan, for they are 1) most directly affected; 2) are generally more knowledgeable as to what can or cannot work, and 3) are in a position to assist in implementation of a pollution mitigation strategy.

E. Comprehensiveness of Existing Legislation.

The Virgin Islands laws referenced above all address issues related to pollution from boats, although some, like the Oil Spill Prevention Act, emphasize oil inputs, while the Port Authority Rules and Regulations are geographically limited to "harbor areas". The Rules and Regulations of the Water Pollution Control Act (Clean Water Act) stand out in that vessels are exempted from obtaining discharge permits, which is appropriate since an attempt to manage boat pollution via a boat specific permit system would be unworkable. Legislative efforts aimed at pollution abatement must be related to the reality and nature of the pollution problem. The principal pollutants from small crafts are sewage, garbage and waste oil, although other not so obvious agents may include heavy metals and other toxic substances.

Of the three principal pollutants, garbage and waste oil can be termed "conservative" pollutants as they cannot be readily assimilated by the environment (i.e., their disposal must be specifically handled to be separated from the environment). Both are reasonably addressed by the Solid and Hazardous Waste Management Act and the Oil Spill Prevention and Pollution Act, although it would have been expected that the former act would specifically address oil pollution control (it does not). The Oil Spill Prevention Act has one operational procedure which should be further examined. It requires that a discharge of oil, or other pollutant prohibited by the act, be reported to the Harbor Master (Port Authority), who then is to notify the DCCA as the local agency responsible for oil pollution control. During an oil spill, time is of the essence in responding to a crisis situation, and the more agencies sequentially involved, the more time is involved in reacting to the crisis.

Sewage discharges, generally a non-conservative pollutant, are readily absorbed by the environment as long as the receiving water is not overloaded. The general effect is enrichment of the receiving water with some risk of health hazards. Whether a certain portion of the receiving water can tolerate the enrichment or whether other uses conflict with such utilization is one of the central issues of coastal water management. No two embayments or anchorages in the Virgin Islands are alike. Each has its own flushing rate, geometry, geo-physical characteristics and types of uses. Where user conflicts and environmental concerns are at issue, the area should be managed on an individual, site specific basis as an "area of particular concern." The Virgin Islands Coastal Zone Management Act is specifically suited for such a management approach. Recommendations for APC's must be forwarded by the DCCA to the Legislature for adoption.

It appears that the two primary mechanisms for dealing with sewage pollution in anchorages are through the above mentioned management approach and through a source control approach, i.e., specifying the degree of sewage treatment for vessels discharging wastes. The latter approach is the objective of the Federal Clean Water Act which directs the U.S. Coast Guard to enforce the Rules and Regulations (for Marine Sanitation Devices) as adopted under the act and is the only legislation which specifically directs itself at pollution source control. The act, of course, has jurisdiction of all vessels in Virgin Islands territorial waters. It further authorizes the U.S. Coast Guard to enter into agreements with state/territorial agencies to enforce the provisions of the Marine Sanitation Devices Standards. Should it be deemed necessary to expand the enforcement standards beyond the capability of the Coast Guard detachment, an agreement with the DCCA/Enforcement Bureau and the Virgin Islands Port Authority could be entered into.

Despite the above "point source" regulation options, the development of an APC management plan and water quality/user monitoring regime for each critical anchorage/harbor remains a critical priority and a vital component of the overall territorial marine resource management plan.

As for the need for new legislation, none is foreseen by the consultants as being essential, except an amendment to the Virgin Islands Coastal Zone Management Act with respect to the jurisdictional extent of the APC's and an amendment of the Water Quality Standards for Coastal Waters of the Virgin Islands.

The APC's are limited to the first tier of the coastal zone, which is a band of land (and water) of varying width along the coastal perimeter of each island. The interior lands, referred to as the second tier, are outside the current jurisdiction of the Coastal Zone Manage-

ment Act. Entire watersheds should be included. The boundaries of the first tier are delineated on the Official Coastal Zone Maps on file at DCCA, Department of Public Works (Building Permit Section), Virgin Islands Planning Office, and the Lt. Governor's Office. It should be emphasized that jurisdictional expansion of only the APC's is suggested, not the entire CZM Act and its permitting processes. This assumes, however, a more rigorous and effective use of the Earth Change permitting process for non-coastal watershed development activity, including road construction and improvement.

Amendment of the Virgin Islands Water Quality Standards for Coastal Waters would be required for those anchorages where the termination of boat sewage discharges are recommended, including Long Bay, Benner Bay, Cowpet Bay, Vessup Bay (inner portion) and Cruz Bay. Under EPA regulations (Title 40 CFR Part 140) such reclassification of discharge classified waters to no-discharge waters must be approved by the EPA. Such approval is contingent upon the Territory's ability to document the existence of adequate pump-out facilities for the safe and sanitary removal and treatment of sewage from boats. Further, it must be demonstrated why such reclassification is necessary and why greater protection than that available under current applicable standards is required. It is clear, however, that such reclassification can only be obtained once the gross and more significant land based pollution sources (i.e., public sewage treatment plant discharges) have been terminated.

F. Agencies Dealing With Vessels, Harbors, and Wastes.

The principal Virgin Islands and U.S. government agencies which have jurisdiction and capability of enforcement over boat pollution are the Department of Conservation and Cultural Affairs, the Virgin Islands Port Authority, the U.S. Coast Guard, and, to a lesser degree, the U.S. Army Corps of Engineers. All of these agencies have some jurisdiction over territorial waters, i.e., to three miles offshore or to international boundaries, except for the Port Authority which is restricted to the harbors of Cruz Bay and Coral Bay on St. John, Charlotte Amalie and Red Hook/Vessup Bay on St. Thomas, and Christiansted, Frederiksted, and the new South Port on St. Croix.

The agencies' physical capabilities and locations are:

	DCCA/ENFORCEMENT BUREAU		PORT AUTHORITY/MARINE DIV.		COAST GUARD	
	St. T./St. J.	St. Croix	St. T./St. J.	St. Croix	St. T./St. J.	St. X
# PERSONNEL ⁽¹⁾	7	6	7 ⁽²⁾	4 ⁽²⁾	10 ⁽³⁾	5
# BOATS	3	2	3	2	1	1
BASE OF OPERATION	Lagoon	Christ'd./Fredk'd.	Charlotte Amalie/Cruz Bay	Christ'd./Fredk'd.	Charl. Amalie	Christ'd.

(1) Field personnel only.

(2) In shifts over 24 hrs.

(3) Three of the ten are assigned to MSD inspection; others are crew of cutter.

It should be noted that the agencies cited carry out other duties than those shown here.

Other agencies, such as the Virgin Islands Department of Public Works, Public Safety, and the Division of Coastal Zone Management (DCCA), as well as the U.S. Environmental Protection Agency, are also directly or indirectly involved; but, due to their lack of boats and marine personnel generally, they are not able to operate on the water and thus must rely on the previously mentioned agencies for support in carrying out their missions.

The activities of the three principal agencies as these relate to boat pollution follow.

1. V.I. DCCA/BUREAU OF ENVIRONMENTAL ENFORCEMENT.

Due to a basic lack of specific jurisdiction and administrative assignment, as well as the general perception that pollution from boats is insignificant, this agency's efforts have not been directed at vessel pollution. More emphasis has been given to the more visible and obvious pollution forms of overboard trash disposal, oil pollution control, endangered species protection, vessel licensing, and disposal of sunken or derelict vessels, the latter being both a pollution source from rusted fuel tanks and a serious navigation hazard in some instances, as well as causing visual pollution. Several cases of sunken, abandoned or derelict boats are pending in the Virgin Islands Territorial Court and are being pursued under the Virgin Islands Water Pollution Control Act. None of the Virgin Islands laws specifically mandate pollution control equipment on boats, but only generally prohibit water pollution.

Further, as noted above, the Rules and Regulations promulgated under the Virgin Islands Water Pollution Control Act specifically exempt boats from the elaborate permit requirements for sewage discharges. Given the fact that localized small vessel underwater sewage discharges are nearly impossible to detect or monitor by current visual and periodic surveillance capabilities, and the fact that no specific Virgin Islands law prohibits incidental sewage discharges from vessels, it appears the principal Virgin Islands marine environmental agency (DCCA) is not, therefore, in a position to manage sewage pollution from boats, except perhaps via an amendment to the individual "household" requirements for "live aboard" vessels.

The potential does exist, however, for the DCCA to obtain necessary jurisdiction under the federal Marine Sanitation Device Standards by entering into an agreement with the U.S. Coast Guard.

2. V.I. PORT AUTHORITY/MARINE DIVISION.

The Port Authority has no specific authorization under the law to prohibit or manage boat pollution disposal practices in the harbors, although the prohibition against oil and other debris being dumped in the harbors is enforceable. The policy of the Authority is to call upon the DCCA Enforcement Bureau in dealing with any environmental matters. However, as noted above, the DCCA has no jurisdiction with regard to sewage discharges from boats. The potential exists for enforcement of the Marine Sanitation Devices Regulations by the Port Authority through an inter-agency agreement with the U.S. Coast Guard. Further, the proposed Regulations under Title 29 prohibit sewage discharges from small boats; however, enforcement implementation is unclear.

However, in discussions with officials of that agency, it was made clear that the Virgin Islands Port Authority does not see environmental management as one of its principal objectives and would prefer to delegate such responsibility to DCCA. An interagency agreement would probably clarify such matters, although DCCA already has the necessary jurisdiction over environmental matters even in the harbors through the Virgin Islands Coastal Zone Management Act and other legislation.

3. U.S. COAST GUARD.

The Coast Guard performs routine boarding inspection of boats to assure compliance with the Safe Boating Law and the Marine Sanitation Device (MSD) Regulations, among other duties. This agency has clear cut authority to inspect and cite vessel owners who are not in compliance with the MSD Regulations. In the past year (1982) the St. Thomas-based Coast Guard contingent carried out over 300 boardings between St. Thomas and St. John and between sixty to seventy-five percent of these boats were found in violation. Violators are cited and cases forwarded to the district hearing officer in the Seventh Coast Guard District in Miami. Presumably the fines of the vessels cited in 1982 have been paid, for the U.S. District Attorney has no records on file for prosecution.

A different situation exists on St. Croix where a small Coast Guard detachment is stationed, whose principal mission is tanker inspection and port safety. Not more than twenty boardings have been made over the last year, with no reported violations. However, the officer in charge estimates that no more than fifty percent of the vessels are in compliance.

The spokesperson for the St. Thomas detachment feels that one additional boat, with three boarding officers, permanently stationed in St. Thomas, is necessary to do an adequate job with respect to the MSD Regulations. The Coast Guard cutter with all personnel is out of St. Thomas more than half of each year, on maintenance and patrol, during which time no boarding inspections are carried out.

Of the three operating agencies which could deal with boat sewage pollution, only the U.S. Coast Guard has clear legal authority and adequate available resources to perform. However, as noted, the cutter (with all personnel including the boarding officers) is on patrol, on search and rescue or drug traffic control missions for extended periods of time and, therefore, out of the immediate area where most of the boats are concentrated in the Virgin Islands (i.e., approximately seventy-five percent of all small craft, less than 100 feet in length, are located between St. Thomas and St. John).

G. Proposed Agency Agreements.

The previous analysis indicated that no new agencies are required to implement any coastal water management plans. Through the expansion of existing authority, existing agencies could carry out the programs of the recommended regulations and management programs.

The following is a review of proposed agency agreements which are now recommended.

1. U.S. COAST GUARD/V.I. DEPARTMENT OF CONSERVATION AND CULTURAL AFFAIRS/V.I. PORT AUTHORITY.

The Marine Sanitation Device Regulations of the Clean Water Act provide for the U.S. Coast Guard to enter into agreements with state/territorial government agencies to carry out the provisions of the Marine Sanitation Device Regulations. It is recommended that such an agreement be entered into between the U.S. Coast Guard and the Virgin Islands Department of Conservation and Cultural Affairs (Bureau of Environmental Enforcement) and the Virgin Islands Port Authority.

The MSD regulations only apply to boats which are equipped with marine sanitation devices; boats which do not have toilets are exempt from the regulations. While this does not present a problem with small boats, which are generally used only for day trips and are not lived upon, it has been found in the present survey that a number of boats, usually residential houseboats without propulsion, are not equipped with toilets, and thus would not be covered by the regulations. These boats are frequently located in sheltered bays with low flushing capability. This specific situation can best be addressed through the APC approach.

2. V.I. PORT AUTHORITY / V.I. DEPARTMENT OF CONSERVATION AND CULTURAL AFFAIRS.

The need for an interagency agreement between the two agencies is twofold: 1) they are both marine regulatory agencies, and 2) their areas of jurisdiction, specifically with respect to environmental concerns, overlap in the harbor areas of Cruz Bay, Coral Bay, Vessup/Red Hook, Charlotte Amalie, Christiansted, and Frederiksted. These harbors also contain most of the boats in the Virgin Islands.

While an interagency agreement between the Port Authority and DCCA will provide for cooperation and reduce conflict, it does not mean that they can enforce each other's rules and regulations. For instance, if the V.I. Port Authority's Rules and Regulations stipulate that boats are prohibited from discharging sewage in the harbors, the Port Authority could not call upon the Enforcement Bureau of DCCA to enforce such provisions, unless the enabling legislation of the Port Authority provides for such. The point is that interagency agreements have legal limitations. Until appropriate management plans for the bays and harbors have been developed, it is difficult to provide further specifics on such agreements. However, the basic goals of such interagency agreements should be optimal use of available resources and the avoidance of effort duplication.

VIII. MANAGEMENT PLAN IMPLEMENTATION.

A. Agencies.

The principal Virgin Islands agency identified for the implementation of the management plan is the Department of Conservation and Cultural Affairs (DCCA) with supporting roles by the Virgin Islands Coastal Zone Commission and the Virgin Islands Legislature.

1. MARINE SANITATION DEVICE REGULATIONS.

The Bureau of Environmental Enforcement within DCCA is the logical choice for the enforcement of the Marine Sanitation Device Regulation, once an agency agreement between it and the U.S. Coast Guard has granted the necessary legal authority to the Bureau. The Bureau is already a water and boat oriented agency through its administration of the Virgin Islands Commercial Fishing Act, Oil Spill Prevention and Pollution Control legislation, the Federal Boat Safety Act of 1971, the Virgin Islands Water Pollution Control Act, the Coastal Zone Management Act, etc. Its staff and budget would, of course, have to be expanded, and this is discussed below.

2. AREAS OF PARTICULAR CONCERN.

The implementation of the APC process is significantly more complex, costlier and would require a much longer time to obtain noticeable results. First, it involves a planning process, some further research, and ongoing environmental monitoring activity. Some of the more diffuse, non-point pollution sources need to be identified in order to take the appropriate corrective action.

Once the necessary baseline information has been obtained, the APC draft plans can be completed by DCCA through its various divisions. The principal participating divisions would include Natural Resources Management, Coastal Zone Management, Fish and Wildlife, and Policy and Planning. Other Virgin Islands government departments which should be involved include Public Works, which has responsibility for sewage systems and administration of the Earth Change Law (soil erosion control in the second tier of the coastal zone); the Virgin Islands Port Authority by virtue of its jurisdiction over harbors; and the Virgin Islands Planning Office through its general responsibilities for land use and overall planning functions.

During the planning process, affected user groups should be consulted and involved for two main reasons: 1) they generally have intimate knowledge of their area of concern and 2) they would be the groups most directly affected by any use regulation. This is not to say that such special interest groups should manipulate the process but should rather be encouraged to assist in achieving established community goals and objectives regarding environmental quality.

Once the APC plans are completed, they would be subjected to public hearings by the Coastal Zone Commission, which then either rejects the plan or approves it and forwards each to the Virgin Islands Legislature, which also would act upon them. If any plan is adopted by the latter, it becomes a legal mandate.

B. Agency Manpower, Budgetary and Time Frame Requirements.

1. MARINE SANITATION DEVICE REGULATIONS AND ENFORCEMENT.

The manpower requirements to carry out meaningful enforcement and education for the effective application of the MSD regulations for reducing pollution impacts are beyond the current capabilities of the Bureau of Enforcement/DCCA, as that agency is now structured and funded. Its present force includes 13 field personnel and five boats for all three islands. This force currently has extensive land and water patrol and inspection duties in natural resources and wildlife protection. It is estimated that the staffing level of the Bureau would have to be increased substantially -- perhaps doubled to carry out the vessel inspection required to enforce the MSD Regulations (personal communication, Chief of Enforcement/DCCA). This would be a continuing task due to the mobility and constant turnover of the vessel population in the territory, requiring a minimal force of perhaps a dozen additional field officers, plus some additional support staff, i.e., clerical, boat maintenance, etc. Perhaps such persons could also be trained to take the periodic water samples and turbidity data at the various sample stations for transfer to the DCCA/DNRM laboratory.

The current operating budget of the Enforcement Bureau is approximately \$200,000 per year; thus, the proposed budget would double to \$400,000 (personal communication, Chief of Enforcement).

The implementation time frame would be closely matched to funding availability, equipment acquisition and personnel training. A minimum of 12 to 18 months would be required to bring such a program on stream. The procurement process for off-island equipment acquisition, such as boats, usually takes about six months, and an effective training program would take six to twelve months to plan and carry out.

2. AREAS OF PARTICULAR CONCERN.

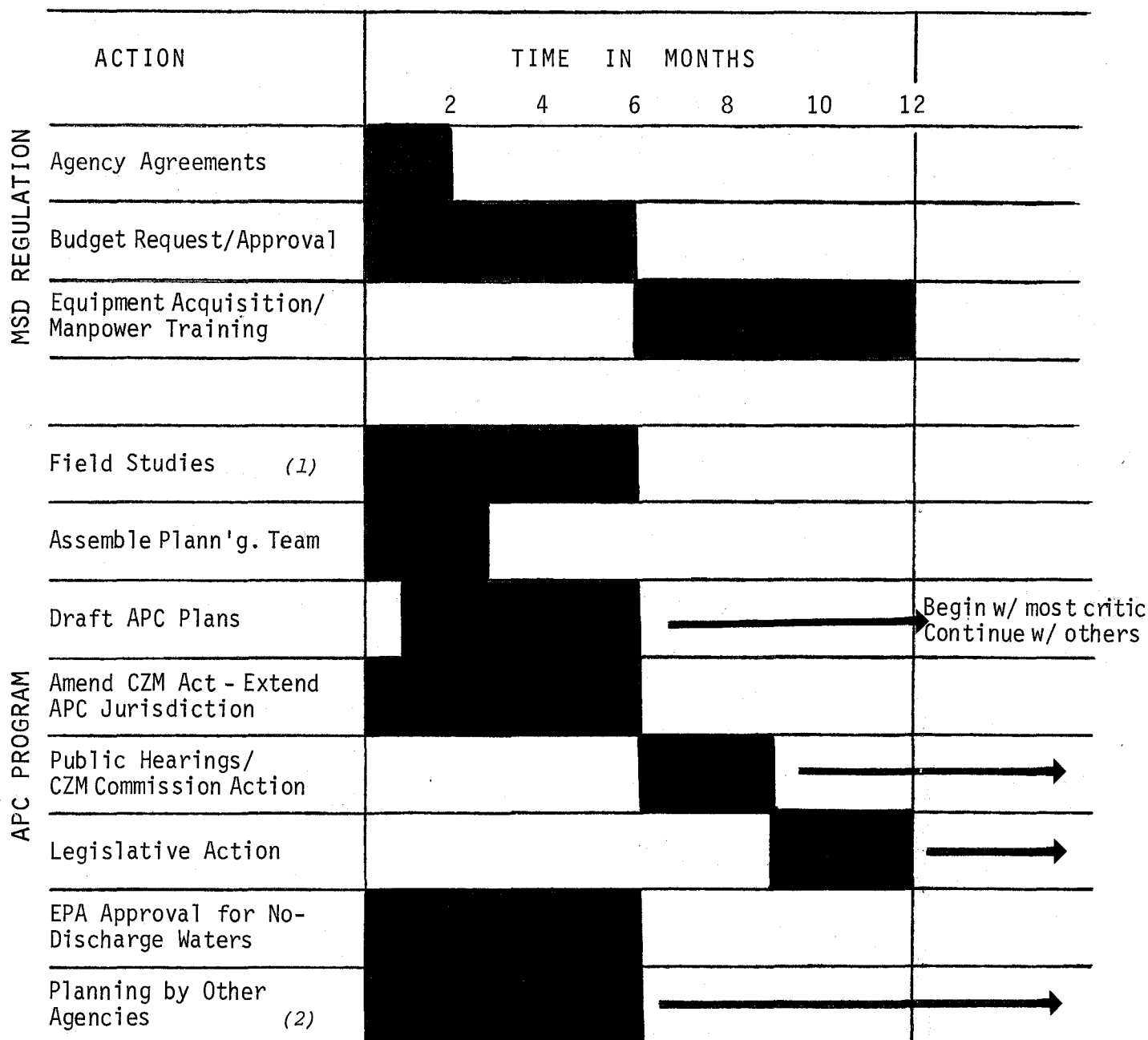
The implementation of the CZM/APC process is clearly far more complex and less subject to manpower, funding and time frame analysis. At the very minimum, a planning team would have to be assembled with the necessary disciplines to cover the variety of subject fields involved. Included should be terrestrial and aquatic biologists versed in tropical ecosystems; an engineer and/or hydrologist who is familiar with man-made systems and how such systems interface with the natural environment; an attorney who is versed in environmental or land use law (as numerous challenges will emerge to confront a program or plan which has no sound legal basis); a qualified resource planner or manager who would be helpful in providing direction and cohesiveness in the planning effort. Related planning will need to take place in other affected agencies, such as the Department of Public Works, to comprehensively resolve existing pollution problems from sewage discharges into coastal embayments.

As noted earlier, further research is indicated to determine the source of the high intensity pollutants occurring in Charlotte Amalie harbor and to determine the impact of septic tanks close to shorelines and of the practice of land irrigation employing sewage effluents. The Division of Natural Resources Management would play a key role in such research, but much of it could be contracted.

Funding for the APC planning process would probably involve a minimum of \$125,000 per year for the professional personnel and supporting staff. If additional office space and equipment are required, beyond what is presently available at DCCA, then that figure would be somewhat higher. To prepare plans for the many stressed and heavily utilized land and water areas would possibly take several years since there are areas beyond those covered in this report which also require attention. Resistance can be expected to such planning from both special interest groups and from those who are unwilling to accept the need for comprehensive resource management and who, therefore, would prefer to continue with the status quo. In any event, environmental awareness and education programs would be needed to gain broad public support.

Funding would need to be identified for the above mentioned research component, as well as for the public participation and Coastal Zone Commission review and approval process. It is not possible, however, to quantify such funding amounts at this time.

FIGURE 12. Program Implementation Time Frame.
(The indicated times are minimums.)



(1) To determine yet unidentified significant pollution sources which manifest themselves through the DCCA/DNRM water quality monitoring program.

(2) To eliminate existing known major pollution sources.

IX. RECOMMENDATIONS FOR FUTURE STUDIES AND IMPLEMENTATION STRATEGIES.

On the surface, the central problem being addressed in this study is the rising level of wastes or pollutants (from expanding numbers of land based and vessel sources) which are injected into a finite number of Virgin Islands bays and harbors with finite spatial dimensions (i.e., acreage) and more or less fixed flushing rates. Each has a fairly unique set or combination of bathymetric features, biological/ecological systems, hydrologic processes, and patterns of human uses and development practices.

On the surface, the solution to the problem appears simple -- terminate the pollutant discharges by some given deadline with the force of law where necessary. Unfortunately, this approach is unrealistic, unworkable and even misses the point. The central environmental problem may well be declining, deteriorating coastal water quality, but the public policy issues involved are far more complex, and the real difficulties are neither environmental or political.

In short, the fundamental problems are (1) scientific uncertainty; (2) public attitudes; and (3) the efficacy of government regulations and enforcement policies.

Any developing or growing continental or insular economy in the 1980's inevitably generates increased levels of air and water pollution and toxic wastes and experiences greater concentrations of people, human activity, and wastes involving more and newer exotic chemicals, technologies and environmental interactions (i.e., systems boundary crossing). The U.S. Virgin Islands is no exception.

The main difficulty is that while the danger of inadvertent pollution excesses lurk everywhere, it is no where very great -- and it normally develops in small increments (with some occasional, locally catastrophic exceptions) which delays the eventual emergence of a public outcry for governmental intervention and action.

For this reason, most moves to regulate and for the design of regulatory activity take place in a crisis atmosphere which is unfortunate and unnecessary. It should be avoided in this instance when developing a vessel waste and anchorage resource management strategy for the Virgin Islands.

The basic elements of a solution can be outlined. None is easily accomplished, but no satisfactory solution will emerge from the process without addressing them.

(1) The first step, and the most important, is a clarification of goals. It is impossible to return the coastal embayments (now vessel anchorages and marina sites, etc.) to their original pristine environmental or ecological condition, and it is equally impossible to reduce environmental risks or even pollutant inputs to zero. Stating (or pursuing) unrealistic goals is counter-productive. It encourages both a crisis orientation (short-term fixes to long-term problems) and, worse still, confrontations -- since environmentalists want the whole protective strategy now and Virgin Islands users (residential, commercial, industrial) see no point in taking costly steps toward an unreachable goal.

What does the Virgin Islands want to do, to preserve, to maintain, to develop, to have for an environment? How much are we willing to give up to enhance environmental quality? Some survey data suggests that the majority of the public supports environmental goals, but not at the cost of a large reduction in living standards or at the cost of significant changes in life styles or traditional, culturally conditioned practices. The public (and this includes both the resource users and the non-users) needs to be better informed about what would be gained by each initiative to protect coastal water quality and what it would cost -- in dollars and in life style adjustments.

(2) A second step requires the improvement of the scientific basis of DCCA, the Virgin Islands Port Authority, the Department of Public Works, and other V.I. agencies making decisions regarding uses of the environmental resource base -- involving natural systems which functioned well until intruded upon by the development process and which have limits and carrying capacities of their own, some of which represent resource planning and management uncertainties.

Agencies can, with scientific help, quantify risks. But the scientific basis of agency decisions can be improved without significant increases in costs or delays. Most important of all, the decision making process is rendered more realistic and defensible.

(3) The third step involves improved implementation and enforcement of environmental protection strategies. There are limits, however, to DCCA's monitoring and enforcement responsibilities regarding existing standards for water quality and other environmental indicators. These responsibilities are hampered by personnel limitations, logistic costs, and jurisdictional constraints. Perhaps an alternative exists, even if partial, that would involve the corporate (and government agency) user conscience -- plus the threats of adverse publicity and lawsuits -- to promote and develop widespread compliance with suggested "voluntary" standards. Further, substituting economic

incentives, such as a sewage waste discharge tax on vessel discharges or on unacceptable MSD's (in certain designated anchorages), could improve targetted vessel waste enforcement, lower its costs and generate revenue to pay for the "enforcement" activity.

In order for DCCA to have access to necessary scientific data to address this growing, long range problem of Virgin Islands coastal water quality deterioration, anchorage management, and the pollution/waste input contribution to this problem, we suggest the following research projects:

- * Watershed Soil Erosion Characteristics for Selected Anchorages - a qualitative and quantitative assessment, with primary emphasis on heavily stressed anchorage areas and secondary emphasis on developing generic Virgin Islands erosion control guidelines which could be applied to other bays, watersheds, and anchorages at a later date.
- * Coastal Zone Land Based Commercial and Domestic Sewage Discharges - The DCCA/DNRM water quality data indicate several significant sewage (fecal coliform) sources, apparently originating on land, particularly in Charlotte Amalie and Christiansted harbors. These sources should be specifically identified (for eventual termination or redirection into the municipal waste collection and treatment system). The role of septic tank effluents and private sector sewage plant effluent irrigation appears to be responsible for both fecal coliform and nutrient inputs into other coastal embayments and needs to be assessed.

Since algae are one of the principal groups of organisms which respond to nutrient enrichment of water, they might be utilized as indicator organisms for certain specific nutrients. The appearance of high concentrations of such algae species in coastal embayments may also be indicative of more serious impending pollution problems. The nutritional requirements of the various species would need to be established through research. The following species have been suggested as possible indicator organisms (personal communication, Dr. LaVerne Ragster, College of the Virgin Islands): Bryopsis, Ulva, Acanthopora, Enteromorpha, Centroceras, and Dictyosphaeria.

- * Rainfall - Water Quality Corrolation - As runoff from land carries with it a pollution load that can adversely impact the coastal water quality and environment, a study of water quality parameters and rainfall should prove useful in assessing the dimensions of this non-point pollution source. A specific monitoring effort should be directed at water quality monitoring of rainfall runoff to obtain a quantitative and qualitative assessment of the pollution characteristics. The urbanized watersheds should receive first priority.

- * Reducing Vessel Waste Discharges: Economic Indicators for Industry Cooperation - a study should be mounted to determine the feasibility of enlisting all users (waste generators) of critical Virgin Islands anchorages, bays, and harbors in a strategy to control or limit vessel waste discharges.

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VESSEL WASTE DISPOSAL QUESTIONNAIRE

This questionnaire is part of a research effort funded by the Division of Natural Resources Management, DCCA and the U.S. Environmental Protection Agency to determine current vessel waste disposal practices and to determine their significance in relation to other pollution sources such as sewer out falls and storm drainage. The BOAT IDENTIFICATION information will be kept confidential.

BOAT IDENTIFICATION (Only one entry, A, B, or C)

A. 1) V.I. Registration Number: VI _____

B. 1) Coast Guard Documentation Number _____
2) Vessel Name _____, 3) Port _____

C. 1) Foreign Vessel Name _____,
2) Registry Country _____, Port _____

***** (CUT HERE)

1. Harbor location - Docked (), Moored ()

2. Type Use: (When more than one use indicate percentage of each)

a) Recreational: 1. Charter - day
2. - term
3. Head boat (glass bottom, harbour cruise, etc.)
4. Dive
5. Sport Fishing

b) Personal Use:

c) Commercial: 1. Fishing
2. Dive
3. Service (deliveries, repair, etc.)
4. Ferry
5. Water Taxi
6. Other _____

d) Other type of Use: _____

3. a) Sail
b) Power

4. Length of Boat

5. Number of berths

Vessel Waste Disposal Questionnaire

6. Useage Characteristics:

- a) Average number of days/month boat is occupied/used in:
1. Harbour _____
 2. V.I. Waters _____
 3. Outside V.I. Waters _____
- b) Average number of persons on board in:
1. Harbour (entry only for liveaboards) _____
 2. V.I. Waters _____
 3. Outside V.I. Waters _____
- c) Most frequently visited location(s) _____
- d) How many months during the past year has the boat resided in the Virgin Islands? _____
- e) If boat is used as a residence, how many persons work ashore . _____
 ENTER: X = none liveaboard; 0=liveaboard but no work ashore; Number=
- f) Are head(s) used while at dock/anchorage - Yes _____ No _____ #work ashore

7. Waste Disposal System:

- | | | Heads | |
|----|--|-------|-------|
| | | 1st | 2nd |
| a) | Sewage: | | |
| 1. | Direct discharge | _____ | _____ |
| 2. | Coast Guard App'd Type I (Macerated - no floating solids) | _____ | _____ |
| 3. | C.G. Type II (Treated before discharge) | _____ | _____ |
| 4. | C.G. Type III (Holding Tank) | _____ | _____ |
| | Where Emptied? _____ | | |
| 5. | No Head | _____ | _____ |
| 6. | Other _____ | | |
| | If pumpout facility were available in your harbor would you use it? Yes _____ No _____ | | |
| b) | Trash: | | |
| 1. | Type of temporary Containment: _____ | | |
| 2. | Final Disposal (Location): _____ | | |
| 3. | Quantity (lbs/week): _____ | | |
| c) | Waste Oil: | | |
| 1. | Final Disposal Site: _____ | | |
| 2. | Quantity (gal/month): _____ | | |

8. Are you the owner (), Captain (), Crew (), Other () (Optional Response)

COMMENTS:

INTERVIEWER: _____

DATE: _____

Docked ()

[illegible]

BOAT SEWAGE

Effects

Although boat sewage can be a repulsive visual pollutant and contribute to the biological oxygen demand of marina waters (38), the primary concern is its potential for carrying disease-causing pathogens. Problems may occur if boat sewage is released in the vicinity of shellfish beds or into enclosed waterways with limited flushing.

At present, total and fecal coliform counts are used as indicators of sewage pollution in waterways. During one summer boating season, Fufari and Verber (17) analyzed water, shellfish and sediment samples from a saltwater cove in Rhode Island (Potter Cove) and reported that the primary source of coliforms was boat waste, although other sources were present, i.e., cows, seagulls. Cassin *et al.* (8) also reported that on Labor Day weekend, coliforms increased in the water column and shellfish in direct relations to a small boat population of an estuarine area on the New York coast. In a comparison study, Barbaro *et al.* (2) sampled marina and non-marina waters during the summer boating season on a Mississippi reservoir. Marina waters contained significantly higher fecal coliform and fecal streptococci counts than non-marina waters (2). Results of a study reported by Seabloom (48) may be contradictory to those conclusions. Coliform counts were taken in two small boat harbors of Washington State. During the boating season, counts increased 11 percent in a small freshwater inlet, but decreased 38 percent in a salt water embayment on Puget Sound. Boat waste studies can be confusing and inconclusive because coliform counts and other measurable effects of boat wastes are influenced by boat densities, the number of people per boat, tides, the day of the week the samples were taken, and other factors (16). In addition, it is difficult to determine if coliforms are from human or animal waste.

Mack and D'Itri (34) studied a freshwater marina area and found that fecal coliforms increased in the dock slips most frequently used by yachts. They also concluded that the number of coliforms was related to the number of yachts in the marina, but no gross pollution was occurring at the marina. In a subsequent study, Mack (33) discovered that the source of a large number of coliforms was actually from local streams feeding into the boating water. Other researchers have found that water quality in some areas is too variable to measure the effect of pollution due to concentrated boat use (58), or that the background levels of coliforms resulting from land-based sewage input were so high that no boating-related impact could be detected (36).

Since coliform counts in surface waters are not always a dependable measure of water pollution by boats (33), Kassebaum (24) explored the possibility of using measurements of coliform concentration in oysters to indicate the impact of boat wastes. Unfortunately, it was found that variation in coliform bacteria concentrations in the oysters was not directly related to boat use in the marina.

Pessoney *et al.* (39) counted *Salmonella* and *Shigella* pathogens rather than total and fecal coliform along the Mississippi coast. While sporadic positive tests were found for the pathogens, they concluded that the water quality in the marinas and harbors tested did not differ greatly from that of the adjacent Mississippi Sound (39).

There is no epidemiological evidence that boat wastes cause disease, but there is the possibility that raw sewage from boats may contain organisms which, when concentrated by shellfish, might transmit disease (16). For this reason, some state health departments restrict the harvesting of shellfish in areas proximate to marinas, even without proof of water contamination (59).

On the federal level, the EPA and Coast Guard have promulgated regulations requiring that vessels with permanently installed heads be equipped, by 1980, with marine sanitation devices (MSD). On inland waters, all boats must be equipped with holding tanks (Type III, devices designed to prevent discharge of any sewage), but those boats on marine and "navigable waters" may utilize devices which release treated sewage (MSD Type I & II) if the effluent meets certain water quality specifications. If these regulations can be adequately enforced, raw sewage from boat wastes will no longer pose a health hazard, but related problems may exist. One of the recommended marine sanitation devices is the holding tank, but it can be too large and cumbersome for some recreational craft and is dependent on the presence of shorebased pumpout facilities (38). Boat wastes from numerous holding tanks can then accumulate at marine pumpout stations, generally to be transferred to municipal sewage systems. Disinfectants used in holding tanks, such as formalin, could become a problem by reducing the normal efficiency of sewage treatment plants (38). An alternative to holding tanks are macerator-disinfectors, which release physically and chemically treated sewage. Proper maintenance of these devices is difficult to enforce and the chemicals used to disinfect the sewage may be more harmful than the raw sewage. No published scientific studies have been found regarding the effects of chemical additives from marine sanitation devices. Preliminary studies (25), however, indicate that these additives could cause significant environmental effects and merit extensive research.

Extracted From G. Chmura and N. Ross, The Environmental Impact of Marinas and Their Boats (University of Rhode Island Marine Memorandum 45, 1978).

Management Considerations

If Coast Guard regulations on marine sanitation devices are to be effective, the public must be made aware of the importance of using and maintaining these devices. Since the number of available pumpout facilities for holding tanks is presently very limited, marina operators should be encouraged to provide more of these facilities. It is clear that not all boats contain permanently installed heads, and those that do may use Type I and II MSDs, which do not require pump-out. Therefore, only selected marinas, in harbors with large numbers of boats containing heads, need to have pump-out facilities available. Marina experience on waterways with enforced holding tank use indicates that existing fuel docks provide the most convenient location for pumpout services.

Regulations concerning marine sanitation devices will be difficult to enforce; thus other management tools are still necessary. In marina waters where higher levels of pathogens could contaminate shellfish, boat toilet use can be reduced if marinas provide shoreside restrooms. These restrooms should be convenient to the docks, provide hot showers and wash basins, and be well maintained. Reasonable guidelines for the required number of toilets need to be established. These guidelines should be based on the capacity of the marina and its use characteristics.

Boat wastes are considered a problem primarily on enclosed inland waters and semi-enclosed coastal waters, where flushing is minimal. In problem areas, boating can be monitored and regulated. Size, depth, tidal flushing and the characteristics of boat use must all be considered to determine the sewage capacity of a waterway. As an example, Fufari (16) has calculated how many boats may be allowed in shellfish areas (assuming a background count of zero coliforms) to maintain standards of 70 coliforms per 100 milliliter of water. Kassebaum (24) also calculated the allowable number of boats to maintain coliform standards, but emphasizes that if such calculations are to be accurate, they must be derived for each water basin on an individual basis.

Once boats are underway and outside of the marina, any sewage discharged overboard is readily diluted, and has a negligible impact. When all boats meet MSD standards in 1980, the potential for contamination of shellfish will be sharply reduced or eliminated. Thus, current restrictions on the harvesting of shellfish from waters adjacent to marinas need to be re-evaluated in light of increasing use of MSDs. Shellfishing should be allowed during nonboating seasons and the shellfish quality should be routinely monitored in marina waters to provide the basis of closure when necessary.

No studies were found on the environmental effects of "gray" water, i.e., galley and shower waste water. Since some concern has been raised about the wisdom of allowing overboard discharge of "gray" water, it is briefly discussed here. This discharge of water, soap, and grime probably has considerably less impact than boat sewage and creates little or no threat of shellfish contamination. However, boat owners concerned about their environment can make use of non-polluting soaps for on-board washing. Until scientific research proves otherwise, discharge of "gray" water does not need regulation.

BOAT MAINTENANCE

Effects and Management Considerations

Regular and seasonal maintenance of boats involves washing, draining bilge water, sanding and painting. All these activities may have minor, but potentially adverse, effects on the marine environment. For example, the amount of detergent introduced into the water when washing boats may be small, but it can cause increased nutrient levels in marina waters and eventually cause a decrease in the dissolved oxygen concentration. Whenever possible, boat owners and marina operators should limit the use of detergents, or use non-polluting detergents.

Individual boat owners can also reduce the amount of petroleum pollutants introduced into the marina when emptying bilge water. In fact, EPA and Coast Guard regulations prohibit the discharge of any oil or oily waste that causes a visible film or sheen on the surface of the water (32). This form of oil pollution can be controlled by the use of oil filtration devices on boat bilge pumps, or devices such as commercial oil-absorbent pads placed in the bilge to soak up fuel and oil before bilge water is discharged. Though pollution by visible oil may be controlled, some petroleum compounds may be dissolved in bilge water and transferred unnoticed to aquatic ecosystems (32).

Other toxic materials may also be transferred to the aquatic environment from the anti-fouling paints which are used on boat hulls, floats and buoys within the marina. After sampling both harbor and coastal mussels, Young (67, 69) found significantly higher PCB (polychlorinated biphenyls) levels in mussels located near centers for the scraping and repainting of boats. Major brands of anti-fouling paint currently used do not contain significant amounts of PCBs, but samples of old anti-fouling paint have shown concentrations as high as 10 percent of the dry weight of the paint (69).

Extracted From G. Chmura and N. Ross, The Environmental Impact of Marinas and Their Boats (University of Rhode Island Marine Memorandum 45, 1978).

Copper is the most common heavy metal used in anti-fouling paints and is found at high levels in sea-water, sediments, and fouling communities in marinas (36). Young (67, 70) found copper concentrations were significantly higher in mussels taken from boat harbors. It has not been estimated at what rate copper is released into the marine environment from antifouling paints, but Young (68) feels that an "important fraction" must be released before repainting. Although copper concentrations have been found to be significantly higher in the marine environment (36, 68), little is known about its transfer through local food chains or long-range impact. Thus, more research is needed on the fate of copper in marina environments, and manufacturers need to develop and market less toxic alternatives to copper-based anti-fouling paints (38).

[IRF Editorial Note:

No counterpart or comparable study of the environmental impact of marinas and boats in the Virgin Islands or even in tropical insular systems has been identified. It is obvious from the ensuing list of literature cited by Chmura and Ross, that most of the available published materials address temperate zone, continental sites and issues which may be instructive (both in terms of biological systems and management consideration) but which should be interpreted and adapted with a certain amount of caution, vis a vis the Virgin Islands and its marinas, harbors, boats and ecosystems.]

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CLASS A

(a) **Best usage of waters:** Preservation of natural phenomena requiring special conditions, such as the Natural Barrier Reef at Buck Island, St. Croix and the Under Water Trail at Trunk Bay, St. John.

(b) **Quality criteria:** Existing natural conditions shall not be changed.

CLASS B

(a) **Best usage of waters:** For propagation of desirable species of marine life and for primary contact recreation (swimming, water skiing, etc.).

(b) **Quality criteria:**

(1) **Dissolved oxygen:** Not less than 5.5 mg/l from other than natural conditions.

(2) **pH:** Normal range of pH must not be extended at any location by more than ± 0.1 pH unit. At no time shall the pH be less than 7.0 or greater than 8.3.

(3) **Temperature:** Not to exceed 90° F. at any time, nor as a result of waste discharge to be greater than 1.5° F. above natural. Thermal policy section 186-5 shall also apply.

(4) **Bacteria:** Shall not exceed a geometric (log) mean of 70 fecal coliforms per 100 ml. by MF or MPN count.

(5) **Dissolved gas:** Total dissolved gas pressures shall not exceed 110 percent of existing atmospheric pressure.

(6) **Phosphorus:** Phosphorus as total P shall not exceed 50 ug/l in any coastal waters.

(7) **Suspended, colloidal, or settleable solids:** None from waste water sources which will cause disposition or be deleterious for the designated uses.

(8) **Oil and floating substances:** No residue attributable to waste water nor visible oil film nor globules of grease.

(9) **Radioactivity:**

(A) **Gross beta:** 1000 picocuries per liter, in the absence of Sr 90 and alpha emitters.

(B) **Radium-226:** 3 picocuries per liter.

(C) **Strontium-90:** 10 picocuries per liter.

(10) **Taste and odor producing substances:** None in amounts that will interfere with the use for primary contact recreation, potable water supply or will render any undesirable taste or odor to edible aquatic life.

(11) **Color and turbidity:** A Secchi disc shall be visible at a minimum depth of one meter.

CLASS C

(a) **Best usage of waters:** For the propagation of desirable species of marine life and secondary contact recreation (boating, fishing, wading, etc.).

(b) **Quality criteria:**

(1) **Dissolved oxygen:** Not less than 5.0 mg/l from other than natural conditions.

(2) **pH:** Normal range of pH must not be extended at any location by more than ± 0.1 pH unit. At no time shall the pH be less than 6.7 or greater than 8.5.

(3) **Bacteria:** Shall not exceed a geometric (log) mean of 1,000 fecal coliforms per 100 ml. by MF or MPN count.

(4) **Taste and odor producing substances:** None in amounts that will interfere with the use for potable water supply or will render any undesirable taste or odor to edible aquatic life.

(5) Other provisions for Class B waters shall apply.

STATUS REPORT AND MANAGEMENT RECOMMENDATIONS
FOR THE VESSUP/MULLER/RED HOOK BAY COMPLEX
AREA OF PARTICULAR CONCERN (APC)

Jerry McCrain
Division of Coastal Zone Management
Dept. of Conservation and Cultural Affairs

July, 1981

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A MANAGEMENT PLAN FOR THE
ST. THOMAS MANGROVE LAGOON AREA
OF PARTICULAR CONCERN



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April, 1981

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SUMMARY

DRAFT HARBOR AND COASTAL WATER USE
PLAN FOR THE U. S. VIRGIN ISLANDS

Draft Plan Available for Public Review

The Department of Conservation and Cultural Affairs (DCCA) has prepared a draft plan for resolving problems associated with the use of V. I. harbors and coastal waters. The draft represents a synthesis of discussions between DCCA, the V. I. Port Authority, and various interested community groups, and is now presented for review and comment by the general public. Written or verbal comments are welcomed at any of the public meetings being held in early September or directly to Marsha McLaughlin, Senior Planner, in DCCA's Policy and Planning Unit, Box 4340, St. Thomas, V. I. (phone: 774-8252).

Purpose of a "Harbor and Coastal Water Use Plan"

Resident and tourist participation in all forms of water-oriented recreation has been increasing rapidly in recent years. Concurrently, there has been considerable expansion of cruiseship and shipping activity as well as water-related transportation, industry, commerce, fishing, and scientific research. In all of the harbor areas and many of the more heavily-used bays, there is beginning to be competition and conflict among such uses, both in the water and on adjacent shorelines.

The intent of this plan is determine measures DCCA should take to ensure wise use of coastal resources, particularly those which are scarce or fragile. While allocation and/or protection of these resources may in some instances be necessary, DCCA is interested both in minimizing "regulation" and in seeking positive ways of promoting balanced use and enjoyment of V. I. waters.

Following is a brief summary of the major coastal water-use problems confronting the territory:

1. Congestion

- a. Harbor and other good boat mooring areas--
Many areas are becoming congested due to increases in the numbers of cruiseships, freight vessels, ferries, airboats, charter boats, dive boats, resident recreational boats, houseboats, transient yachts, sightseeing vessels, floating

shops, etc. New and traditional uses are in competition for available space.

b. Swimming Areas--

Many of the more popular bays are heavily used not only by swimmers and picnickers, but also by windsurfing, sailboat and peddleboat concessions, dive tour operators, charter boats, resident recreational and fishing boats, sight-seeing vessels, etc.

2. Safety

a. Navigational Areas--

In some areas, the demand for boat anchorage is so high that boats are infringing on the channels needed for navigation by boats or airboats. Such encroachments are potentially hazardous.

b. Swimming Areas--

In some heavily-used areas, the safety of swimmers is being jeopardized by boat traffic, water-skiing, windsurfing, beach fishing, spearfishing, and fish cleaning.

3. Environmental Problems

a. Water Quality--

The areas which are heavily used by boats are subjected to increased pollution (eg., sewage, turbidity, oil, and heavy metals). In the more enclosed bays with low flushing rates, water quality is becoming a problem.

b. Fish and Wildlife--

In some areas, boat mooring and anchoring practices are damaging fragile grassbeds, coral reefs and mangroves stands. This is diminishing (and in conjunction with water quality problems can destroy) their value as habitat for birds and all forms of marine life.

c. Aesthetics--

Water-related activities have produced air, noise, and visual pollution problems in some areas. In many others, a peaceful natural character is giving way to a busy and congested atmosphere.

Joint Governmental Responsibility

Governmental responsibility for resolving these water-related congestion safety, and environmental problems is divided between the V. I. Port Authority (VIPA) and the Department of Conservation and Cultural Affairs (DCCA). Several federal agencies (U.S. Coast Guard, Environmental Protection Agency, and the U. S. Dept. of Interior-Bureau of Fish and Wildlife) have responsibility of a supporting nature. VIPA and DCCA, however, have lead responsibility for managing the use of coastal waters.

The Port Authority has primary jurisdiction over navigation and use of harbor areas (eg., Charlotte Amalie, Red Hook, Cruz Bay, Christiansted, and Frederiksted). DCCA has responsibility for boat mooring throughout the territory, boating registration, and safety, plus air and water pollution control. DCCA also has broad jurisdiction under the V. I. Coastal Zone Management Act; notably, environmental protection and the orderly, balanced utilization of coastal zone resources.

DCCA and the Port Authority are concerned about resolving congestion, safety, and environmental problems, where such problems exist. Use of the vast majority of coastal waters will remain unregulated until there is a need for controls (see following chart).

PROBLEM AREAS AND ISSUES

Problem Areas	Problems			Key Activities and Concerns					
	Congestion	Safety	Environmental	Navigation	Freight Vessel/ Cruiseships	Fishing Boats	Other Boats	Swimming and Other Water Sports	Environmental Protection
<u>St. Croix</u>									
Christiansted	X	X	X	X	X	X	X	X	
Cane Bay	X	X						X	
Frederiksted		X		X	X				
Tague Bay		X						X	
Cramer Park		X						X	
<u>St. John</u>									
Cruz Bay	X	X	X	X	X	X	X	X	
<u>St. Thomas</u>									
Brewers Bay		X						X	
Lindbergh Bay		X						X	
Honeymoon Bay) Water	X	X					X	X	
Flamingo Bay) Island	X		X				X		
Crown Bay	X			X	X		X		
St. Thomas Harbor	X	X	X	X	X	X	X		
Morningstar Beach		X						X	
Bolongo Bay		X						X	
Mangrove Lagoon			X						X
Benner Bay	X	X	X	X			X		X
Buck Island	X	X						X	
Great St. James	X	X						X	
Cowpet Bay	X	X		X			X	X	
Red Hook Bay	X	X	X	X	X		X	X	
Sapphire Bay	X	X						X	
Pineapple Bay	X	X				X		X	
Coki Point	X	X						X	
Magens Bay	X	X	X			X		X	
Hill Bay	X	X				X		X	

SUMMARY OF PROPOSED WATER USE POLICIES AND STRATEGIES

WATER USE POLICIES

STRATEGY

tion Areas	1. VIPA will designate and mark boat channels and airboat flyways in harbors. 2. DCCA will mark Mangrove Lagoon channel. 3. No anchoring/mooring of small boats.
t Vessel and Cruiseship Areas	1. VIPA will designate areas for freight vessel and cruise-ship anchoring.
y Boat Areas	1. DCCA will designate traditional mooring and shoreline storage areas. 2. DCCA will allocate space (via mooring permit system) to applicants who have a commercial fishing license and have paid the V. I. water user's fee.
tional Boat Areas	1. DCCA and VIPA will designate areas for reserved permanent mooring and temporary anchoring. 2. Institute "reserved" permanent mooring system: • Permittee shall install, maintain, and be liable for his mooring (subject to performance standards). • Space will be allocated to those in the area first and then to others in order of application and by size. • Permits will be granted either for single boats or for multiple boats (licensed brokers and charter firms). All permits will be one-year term; renewable. • Fees will be charged and must cover the cost of enforcing reserved mooring rights, regulations on speed and accidents, increased water quality monitoring. They must also compensate the public for loss of use of privately occupied public trustlands (submerged lands). Costs for services, if any, will also be included (see proposed fee structure at end).

WATER USE POLICIES

STRATEGY

	3. Institute Temporary Anchoring System • Space will be available on a first-come-first-serve basis. • Permission to anchor will be granted by DCCA or VIPA for a limited duration (3 to 14 days per month). • Fees may be charged to cover the cost of services (if any) provided. DCCA does not propose to charge a fee at this time.
Swimming Areas	1. DCCA will designate areas reserved for safe swimming and snorkeling. Where appropriate, accessway(s) for spearfishers, windsurfers, dinghies, and other small craft may be designated. 2. DCCA will develop regulations restricting fishing, windsurfing, and boating in designated swimming areas. Where necessary, boating, spearfishing, and commercial fish cleaning may be restricted in adjacent areas. 3. DCCA will install swimming buoys for beaches where it has facilities. In other areas, individuals or corporations installing swimming buoys will receive waiver of CZM permit application fee and annual submerged lands fee. 4. DCCA will provide enforcement.
Environmental Protection Areas	1. DCCA will designate sensitive ecosystems, habitats and water quality problem areas, as well as areas of unusual scenic quality or value to the public. 2. DCCA will develop regulations for such areas as needed.
Unrestricted Areas	1. No action at this time. Free use by all vessels and users within limitations of existing regulations (eg., boating safety, water quality, wildlife, fisheries, etc.)

WATER USE POLICIES

STRATEGY

Comprehensive Water User's Fee

1. Extend V. I. boat registration to:
non-motorized boats
fishing boats
transient boats -- which must register within 60 days of
entering V. I. waters
2. Institute Comprehensive V. I. Water-User's Fee:
 - Institute a water-user's fee to cover the costs associated with water usage (eg. , boat safety, search and rescue, water quality and oil spill programs, fisheries regulations, installation of swimming buoys, tracing the ownership of derelict vessels and other environmental regulations), as well as to reimburse the public for private occupancy of submerged public trustlands.
 - This fee will apply to both private boats and the following commercial water users: freight vessels, passenger vessels, commercial and sport fishing boats, traditional small fishing boats, charter boats, dive boats, and water-use concessions (eg. , small craft rental, shore-based dive tours, etc.).
 - DCCA proposes that all proposed commercial water-uses be reviewed for their impacts on both coastal resources and on existing uses in the area prior to being granted permission to operate.
 - Fees--the traditional V. I. boat registration fee will be incorporated into the new fee structures (see last page).