VIRGIN ISLANDS RESOURCE MANAGEMENT COOPERATIVE

BIOSPHERE RESERVE
RESEARCH REPORT NO. 24

RECREATIONAL USES OF MARINE RESOURCES IN THE VIRGIN ISLANDS NATIONAL PARK AND BIOSPHERE RESERVE: TRENDS AND CONSEQUENCES

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U.S. MAN AND THE BIOSPHERE PROGRAM

Virgin Islands National Park

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The Virgin Islands Resource Management Cooperative (VIRMC) was formed in 1982. Signatories to the Memorandum of Understanding are: Virgin Islands National Park, the Department of Planning and Natural Resources of the U.S. Virgin Islands Government (Division of Fish and Wildlife and Division of Natural Resources Management), University of the Virgin Islands, West Indies Laboratory, Island Resources Foundation, Eastern Caribbean Natural Area Management Program, U.S. Geological Survey, U.S. Fish and Wildlife Service, Southern Forest Experiment Station, University of Puerto Rico (Sea Grant Program and the Center for Energy and Environment Research), Caribbean Fishery Management Council, the Ministry of Natural Resources and Labor of the British Virgin Islands Government, and the British Virgin Islands National Parks Trust.

The objectives of the cooperative are:

1. To establish a Virgin Islands Resource Management Cooperative for the purpose of providing coordinated research, extension, and educational support of programs to achieve full benefits of island forests, wildlife, water resources, the marine environment, and historic areas and their associated resources for their cultural, social, commercial, economic, and recreational utilization and enjoyment.

2. To provide for the direction and management of the Cooperative by forming an Executive Committee, comprised of one representative from each of the organizations who are parties to this agreement, which will a) elect annually a Chairman from the membership of the Executive Committee to serve for a term of one year, b) appoint an Executive Officer to a staff position to coordinate the work of the cooperative, c) appoint technical committees and project leaders, d) provide for the orderly process of development and implementation of policy, and e) foster cooperative activities and relationships among participating parties and with other agencies and institutions.

3. To coordinate and facilitate financial and other support for research on environmentally acceptable uses of forests, wildlife, the marine environment and historic areas, and their associated resources in order to provide for their better management.

4. To provide for the collective utilization of the unique attributes and resources (personnel, facilities, equipment, and other support services) of the parties as they may relate to objectives pursued under this agreement.

5. To plan for appropriate dissemination, publication, and application of research and information.

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ABSTRACT

Recreational uses of the waters and beaches of Virgin Islands National Park and Biosphere Reserve on St. John, U.S. Virgin Islands, have increased dramatically in the last 10 years. Recreational visits to the park have risen from less than 100,000 prior to 1967 to over 750,000 in 1986. Annual visitation to Trunk Bay beach, the most heavily used beach in the park, has risen from under 20,000 people in 1966 to almost 170,000 in 1986. The average number of boats per day in park waters increased from less than 10 in 1966 to about 80 in 1986.

One consequence has been the degradation of the park's marine resources, particularly some of the coral reefs and seagrass beds along the north shore of the island which receives the heaviest use. Anchor damage and damage from boats striking or grounding on reefs is evident. Seagrass beds in popular bays have deteriorated.

Based on field work and examination of National Park Service (NPS) records, this report documents some of the trends and consequences of increased recreational uses of the park's resources and some recent efforts to protect them. Its purpose is to provide a basis for future management actions designed to balance increased visitation with protection of fragile marine resources.

ACKNOWLEDGMENTS

Many people assisted us with this project. We especially appreciated the efforts of Dan Cooke, David Vekasy, Ken Blonder, and Joe Luttman. John Miller, the park's Resources Management Specialist, assisted in several aspects of the work. Rafe Boulon's concern over damage from boat groundings was largely responsible for increasing our awareness of unacceptable reef destruction in the park. We thank him for assisting with installation of marker buoys and for supplying useful records for Windswept Reef. Thanks also to Chief Ranger Larry Guth and Supervisory Park Ranger Richard Jones for supplying National Park Service records and assisting us with their interpretation.

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INTRODUCTION

Throughout the Caribbean, tourism and coastal development are exerting severe pressure on the natural resources of many islands and countries. More and more tourists are visiting parks and protected areas in the region. The purpose of this study was to document the trends in recreational uses of the waters and beaches of Virgin Islands National Park and Biosphere Reserve on St. John, U.S. Virgin Islands, and to assess the degradation of the marine resources attributable to recreational activities. Robinson (1973, 1976) drew attention to environmental damage associated with recreation in Virgin Islands National Park in the 1970's, prior to the dramatic increase in visitation.

Virgin Islands National Park (VINP) consists of 2,816 ha of federally owned land on St. John, and 2,287 ha of marine waters (Fig. 1). The terrestrial area of the park was established in 1956. In 1962, the park boundaries were expanded "...in order to preserve for the benefit of the public significant coral gardens, marine life, and seascapes..."(16 U.S.C. 398). Both northern and southern waters were added to the park at this time.

This study focused primarily on documenting the increase in the number of boats visiting VINP and on evaluating the environmental damage associated with boating. Recreational fishing can adversely affect not only fish and shellfish populations but also the reefs themselves, e.g., when fish traps land on and smash coral colonies and divers overturn corals to extricate lobsters. Unfortunately, lack of information on the magnitude of recreational fishing and changes in the intensity of fishing over time preclude its evaluation here. This study was one of several Virgin Islands Resource Management Cooperative (VIRMC) projects conducted between 1984 and 1987 which were designed to provide the information necessary to manage the coral reefs, seagrass beds, and fisheries of St. John.

METHODS

Assessment of trends and impacts from boating and other recreational uses of marine resources was based on fieldwork at selected sites around St. John and analysis of National Park Service documents, specifically Boat Patrol Logs, Monthly Public Use Reports, Case Incident Records, and Lifeguard Logs.

Field observations of damage to marine resources

Study sites Recreation in VINP waters is concentrated most heavily in the northern and northwestern bays. Consequently, we selected Solomon, Honeymoon, Caneel, Scott, Hawksnest, Trunk, Cinnamon, Maho, Francis, and Leinster Bays (Fig. 1) for studies of anchor damage (see below).

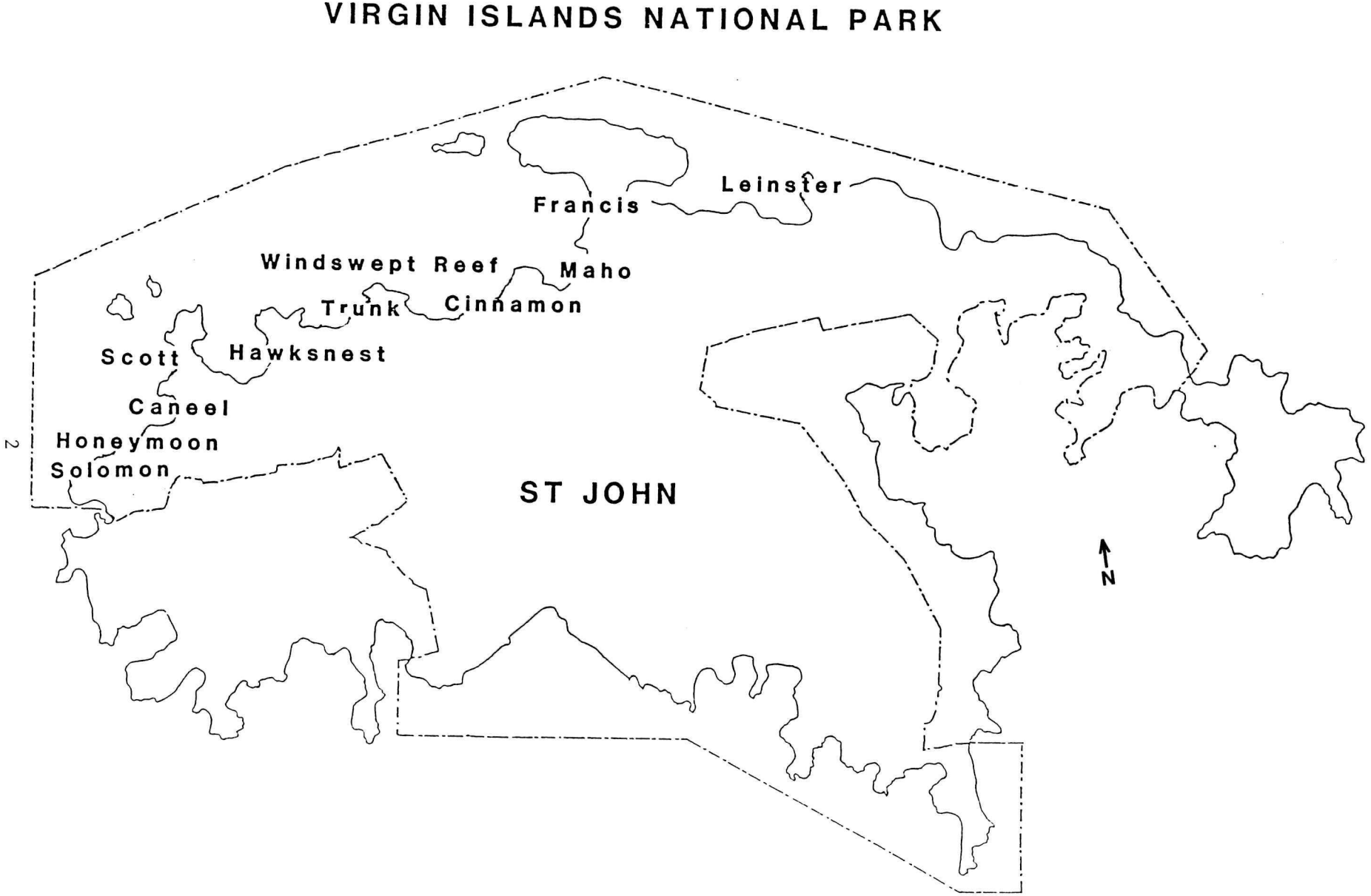


Figure 1. St. John study sites. Broken line indicates boundary of Virgin Islands National Park.

Observations by park staff and others indicated that Windswept Reef and Hawksnest Bay patch reefs (Figs. 1, 2) have suffered severe damage from boats striking or running aground on the reefs. Windswept Reef fringes the point which lies between Trunk and Cinnamon Bays, two of the most popular bays in the park. Hawksnest Bay has become an increasingly popular anchorage, particularly for day sailors. An increase in the number of snorkelers is also resulting in more damage to coral colonies. These reefs are extremely shallow, making them particularly vulnerable. Windswept Reef and four patch reefs in Hawksnest were examined on a monthly basis for evidence of physical damage. Boats do not generally anchor on the Windswept and Hawksnest Reefs, and most damage is from boats running aground or from snorkelers.

Breakage of coral colonies: Windswept and Hawksnest It is very difficult to quantify physical damage to coral reefs, whether from anchors, boat groundings, careless snorkelers, or other causes, because of their structural complexity. The shallowest reef areas, where much of the damage occurs, are especially hard to survey because they are impossible to swim over. We estimated damage by swimming parallel transects across the reef areas and counting the number of freshly broken branches of elkhorn coral, Acropora palmata, and by measuring the "length" and "width" of each fracture area or stump (Rogers et al., 1982). (No attempt was made to swim the same transects on each survey, although the entire reef was surveyed each time.) Because most fracture areas were elliptical, the length and width measurements were used to calculate areas using the formula for an ellipse (Area = length x width x 0.8). Acropora palmata is the most abundant coral on these study reefs and suffered the most breakage. We considered it important to estimate the area of the branch fractures because physical damage is a function of both number and size of breaks.

Making observations at monthly intervals proved most effective in assessing damage. With greater frequency, it is often not possible to differentiate fresh breaks from older ones, and breaks could be counted more than once. Algae rapidly grow over freshly broken areas (sometimes within one week), and if the observation intervals exceed a month, breaks occurring since the last observation will no longer be discernible.

In addition, from June 1985 until January 1987, Rafe Boulon, from the V.I. Division of Fish and Wildlife, kept records of the number of boats which struck or grounded on Windswept Reef which lies below his house on Windswept Point.

Anchor damage survey The purpose of the anchor survey, performed between January and March 1987, was to assess damage and potential damage caused by boats anchoring in National Park waters. For each bay surveyed, the following information was collected: time of survey, boat length, type of boat, type of anchor, length of anchor chain, amount of chain resting on the bottom, bottom type (coral, seagrass, sand, rubble, pavement, and

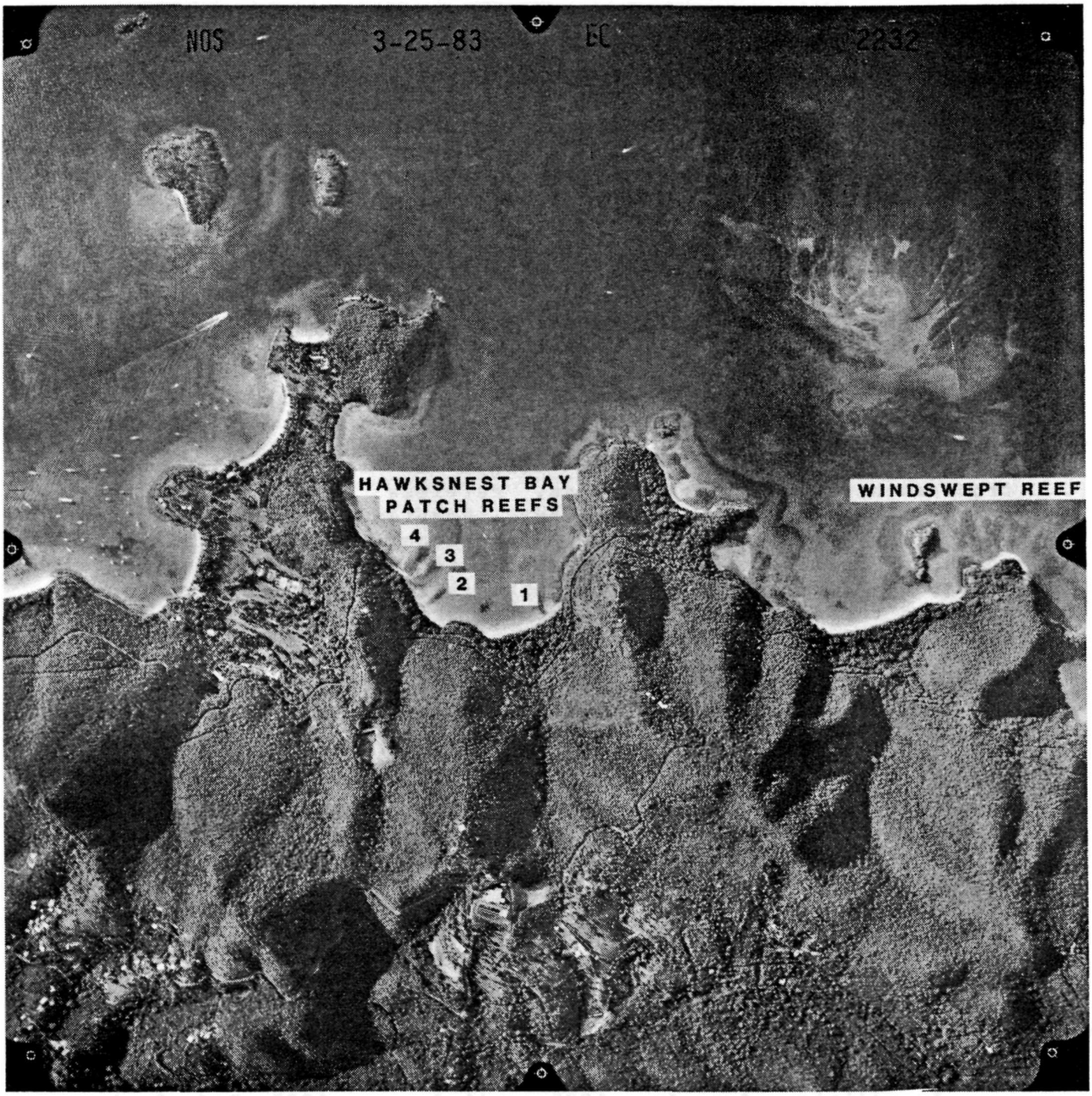


Figure 2. Aerial photograph showing locations of Windswept Reef and Hawksnest Bay patch reefs 1 - 4.

mud). Damage observed was given a subjective rating of negligible to severe.

Examination of National Park Service records

Boat patrol logs and monthly public use logs National Park Service rangers patrol the northern and western waters of the park almost daily, recording the number of boats in each of the several bays. The data are summarized and incorporated into monthly public use logs. Unfortunately, boat patrol logs for individual days are available only from 1984-1986, and we can not trace trends in the number of boats in specific bays prior to these years. However, we used figures for the total number of visitors on boats in park waters each month from the public use logs to calculate the average number of boats per day in the park from 1966 to 1986. In most cases, rangers estimated the total number of visitors using a formula which assumed five passengers per boat. However, the same formula was not consistently used prior to September, 1981, and we can not determine the actual number of boats each month because the raw data were discarded. (The different factors used for passengers per boat could possibly result in discrepancies of as much as 20% in the final totals.) Consequently, graphs of the data presented below should be used only as indicators of trends.

Aerial photographs taken over several years were used to discern the trend in numbers of boats in several St. John bays. For most years, photographs were taken on just one day. Clearly, this method has many biases, e.g., inconsistencies in time of day photographs were taken or season of the year, but it is another source of historical information.

Monthly public use logs were also used to estimate the total number of visitors to the park from 1971 through 1986 and to obtain information on the use of Trunk Bay beach, the beach on the north side of the island which has the heaviest use. For 1980 through 1986, we added figures for land-based tours (transportation of people in large taxi-buses) and other individuals on the beach (derived from logs kept by the lifeguards) to arrive at a figure for total number of visitors to Trunk Bay each month. The format for the monthly report was changed in 1979. Consequently, for the years prior to 1980 we estimated the use of Trunk Bay by adding 56% of the total beach visitors for several park beaches to visitors associated with the land tours. (We derived this percentage from the 1980 data which had specific values for Trunk Bay as well as totals for all beaches which were considered.) Once again, the figures are approximate and based on some assumptions, but the trends are evident.

Case incident records National Park Service employees use Case Incident Records to document the circumstances of a variety of non-criminal events. We reviewed records from 1976 to 1987 for evidence of damage to natural resources (for example, taking of

reef organisms as souvenirs) or of conflicts arising from the different uses of park waters and violations of regulations designed to protect natural resources.

Lifeguard logs Lifeguard logs are filled out daily at Cinnamon and Trunk Bay beaches. They are available only for certain months from 1981-1986. Because the logs were not filled out consistently and completely, they provide limited information on such things as removal of marine organisms, number of boats entering restricted areas, and number of people standing on coral colonies near the underwater trail at Trunk Bay.

RESULTS

Coral breakage at Windswept and Hawksnest Reefs

Graphs of the number of broken coral branches and the mean area per break at Windswept and the Hawksnest reefs indicate damage to A. palmata colonies from careless snorkelers, boat strikes, and heavy swells (Figs. 3, 4). In the winter of 1986, northern swells appeared to be the major cause of damage, particularly at Windswept Reef. Many of the elkhorn colonies had small fractures at the tips of their branches. Larger breaks seemed to be associated with boat damage and frequently bore patches of anti-fouling paint from the bottoms of boats which had struck or grounded on the reefs. In some cases, for example in October, 1986 on Hawksnest patch reef 3, a boat had caused so much structural damage (over an area of about 100 m^2) that it was impossible to quantify it. Also, on Windswept Reef in December, one boat remained on the reef for four days, after which it was dragged off across the corals.

Three large marker buoys were installed along the seaward edge of Windswept Reef on May 30, 1986, to warn boaters of the reef's location. Observations following placement of the buoys indicated a decrease in the number of broken coral branches until December when heavy northern swells rolled into the reef. Records provided by Rafe Boulon showed that at least 23 boats hit the reef from June 1985 until May 1986, while only 2 boats were observed to hit the reef following installation of the marker buoys (Appendix I).

Anchor damage survey

Of the 186 boats surveyed, 32% were anchored in seagrasses and 14% in coral communities, with the remainder on sand, mud, or pavement. Many sites which now have barren sand or pavement could previously have had seagrass beds or coral communities which deteriorated with an increase in anchor damage. Of the 26 anchors found on coral bottoms, 7 (27%) were causing minor damage and 3 (12%) were causing moderate or severe damage, with the rest causing no apparent damage. Of 60 anchors in seagrasses, 18 (30%) were causing minor damage, and 17 (28%) moderate or severe damage, with the rest causing no apparent damage.

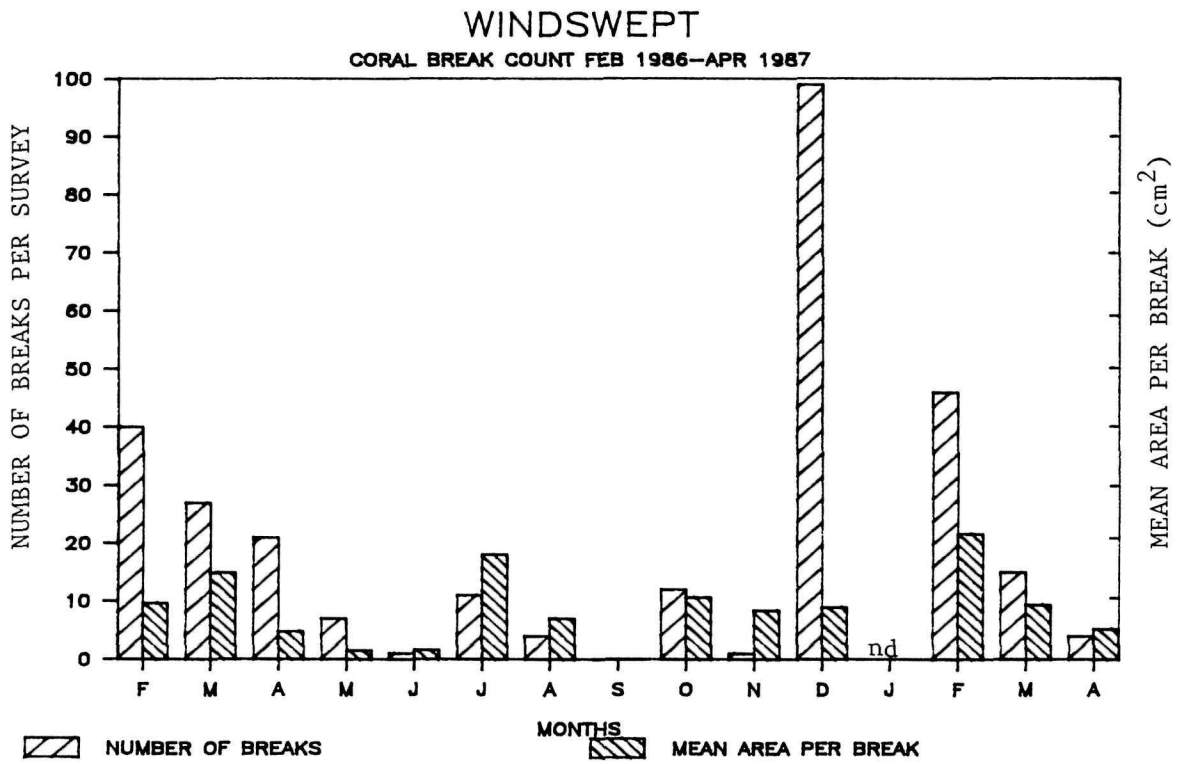
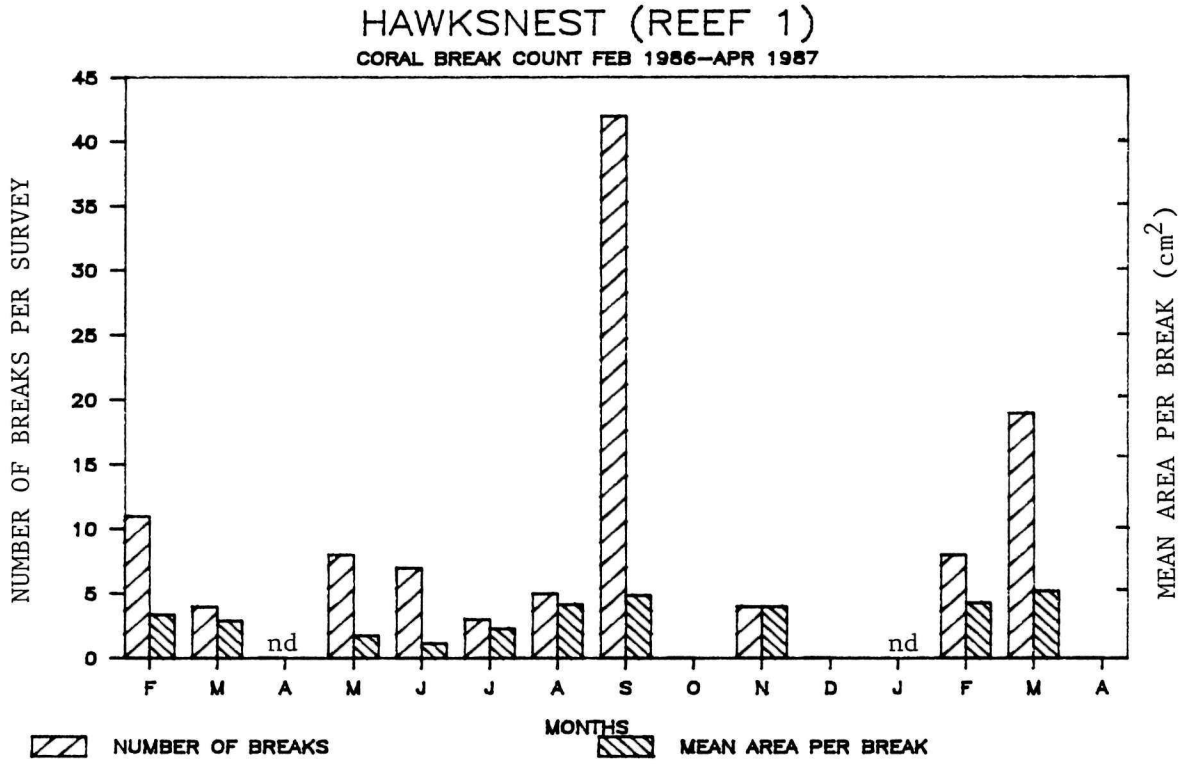


Figure 3. Coral breakage at Windswept Reef. Absence of a bar indicates there were no breaks. nd = no data.



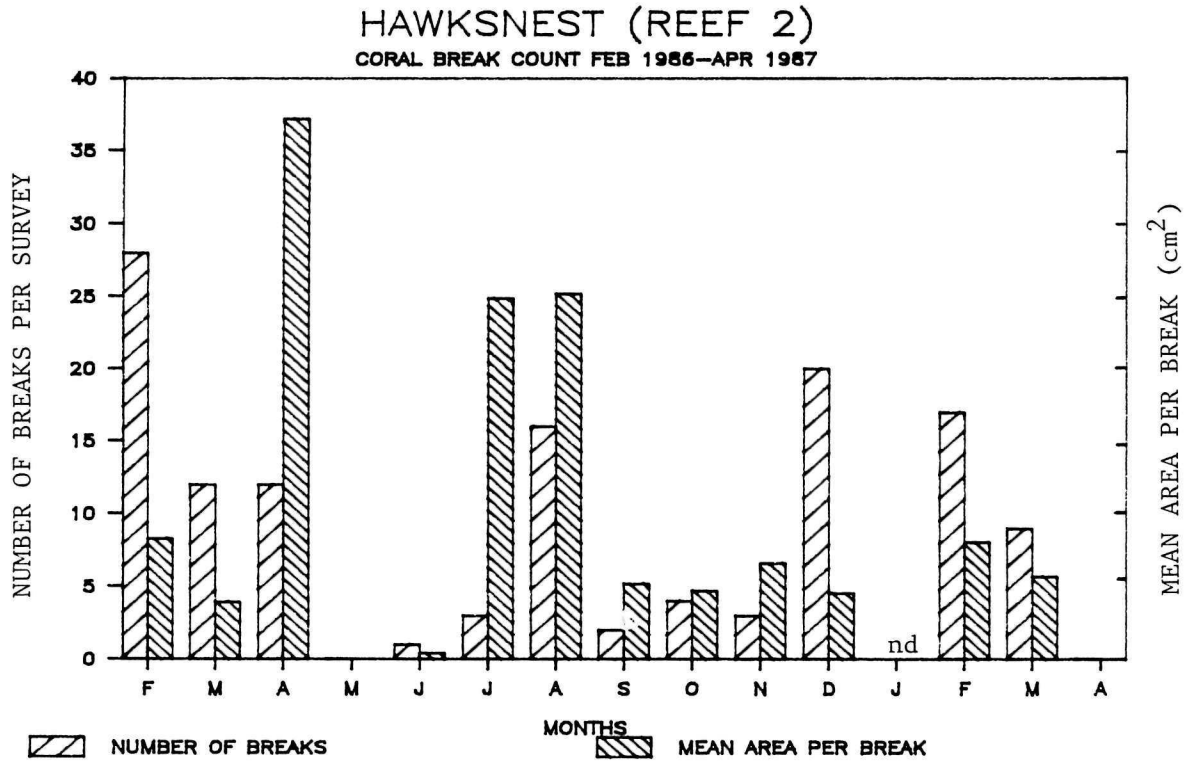
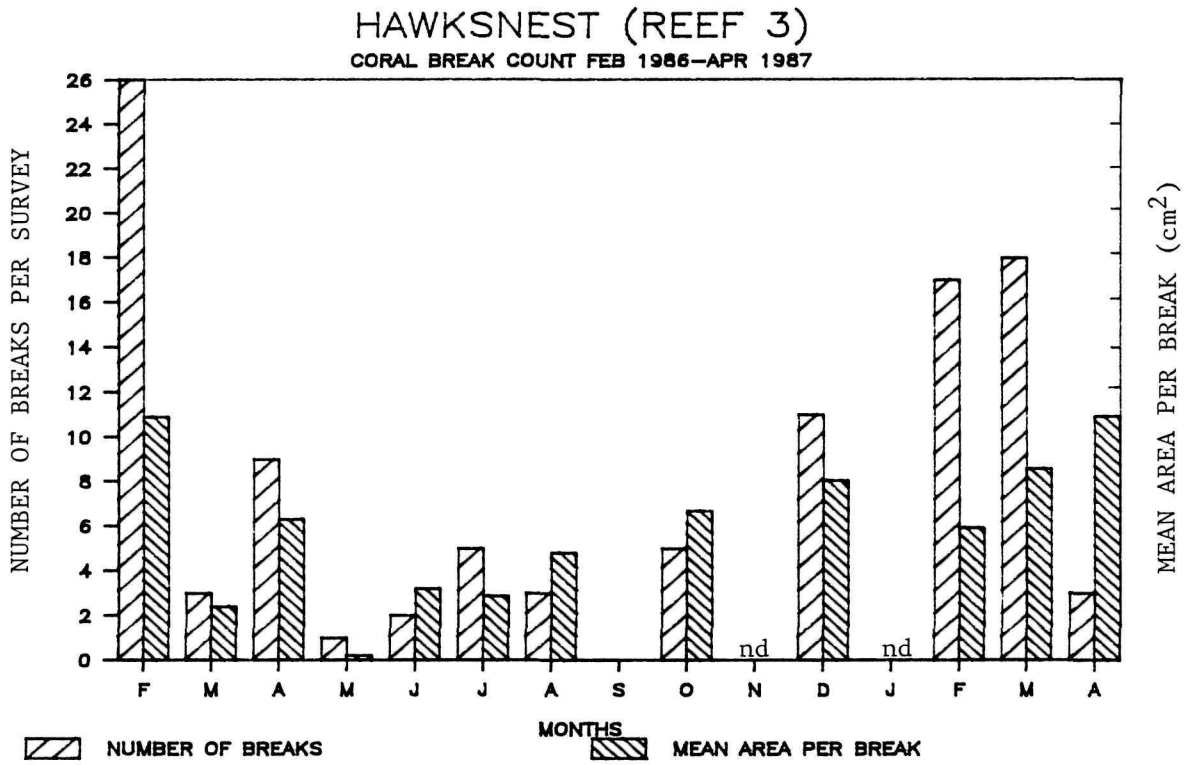


Figure 4. Coral breakage at Hawksnest Bay patch reefs 1 - 4.



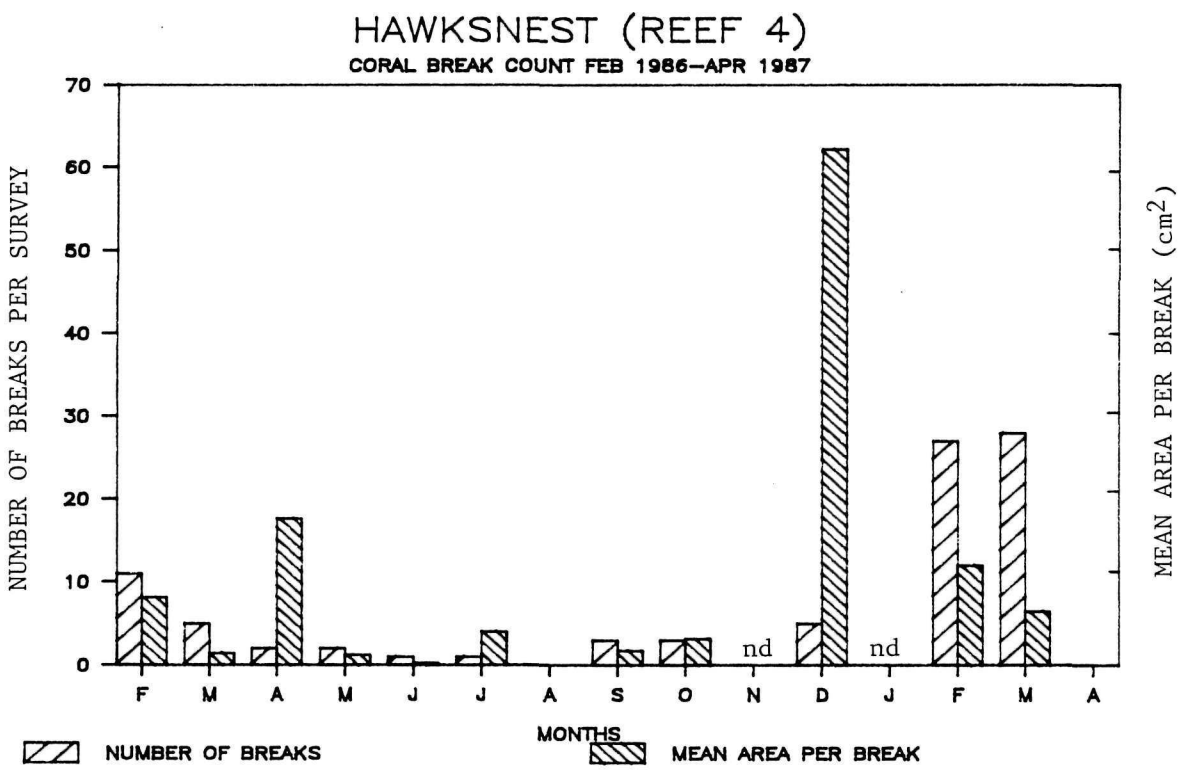


Figure 4. (continued)

About 56% of the boats were anchored in 5 m or less, 39% in 6-10 m, and 6% in 11 m or deeper water. In general, the deeper the anchor, the less likely it was to be found on sensitive coral or seagrass communities (Figs. 5a, 5b, 5c) which tend to occur near shore in most of the bays surveyed.

More disturbance to benthic communities is often associated with the chain attached to the anchor than with the anchor itself. As the winds and currents shift, a boat can swing through a complete circle with concomitant disturbance to the bottom from the sweep of the anchor chain. Consequently, there is the potential for 60 ha of bottom to be damaged each year at current use levels, based on an average chain length of 7.7 m, and almost 30,000 boats per year.

Trends in uses of park beaches and waters

Park visitation The estimated number of recreational visitors to the park climbed from less than 100,000 prior to 1967 to over 750,000 in 1986 (Fig. 6). Comparison of the number of recreational visitors on a monthly basis for 1966, 1976, and 1986 clearly shows a dramatic increase and, at least for 1976 and 1986, some seasonality in use patterns (Fig. 7). Most people come to St. John in the winter with March the peak month. There is a decrease in the spring, with a jump in July corresponding to the 4th of July weekend. September and October are the slowest months.

Trunk Bay beach and underwater snorkeling trail Trunk Bay beach is the most heavily used beach on St. John. Estimates indicate an increase in annual visitation from just under 20,000 people in 1966 to almost 170,000 in 1986 (Fig. 8). Sometimes over 1,000 people are on the beach on a given day. One of the main attractions is the underwater snorkeling trail established in the early 1960's. According to park staff and residents of the island, the trail has deteriorated substantially as a result of people standing on corals, breaking coral branches while snorkeling, and removing organisms as souvenirs. Lifeguards report frequent removal of sea fans and corals, although examination of their logs reveals few formal records of such incidences. In one month alone, lifeguards observed over 200 people standing on corals, most of them near the underwater trail. The logs do not indicate if they were on living or dead coral, but even standing on dead coral can be detrimental because it is a good substrate for new coral settlement and growth. The cruise ship "Norway" began visiting St. John in December 1986, and a few hundred passengers are transported one day every week to Trunk Bay, where they snorkel on the reef in the western portions of the bay and down towards adjacent Jumbie Bay. The impact from snorkelers is consequently no longer concentrated only at the underwater trail. Some people have recommended closure of the Trunk Bay trail to allow it to recover. However, we do not think it advisable to close this trail now and open another trail for visitors. Robinson (1973) noted 14 years ago

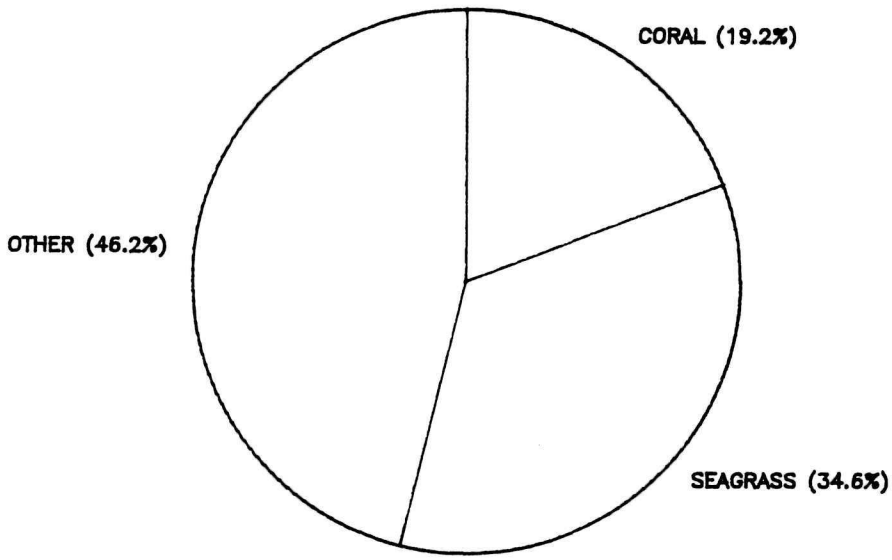


Figure 5a. Bottom type for boats anchored in 0 - 5 meters in northern and western bays of St. John.

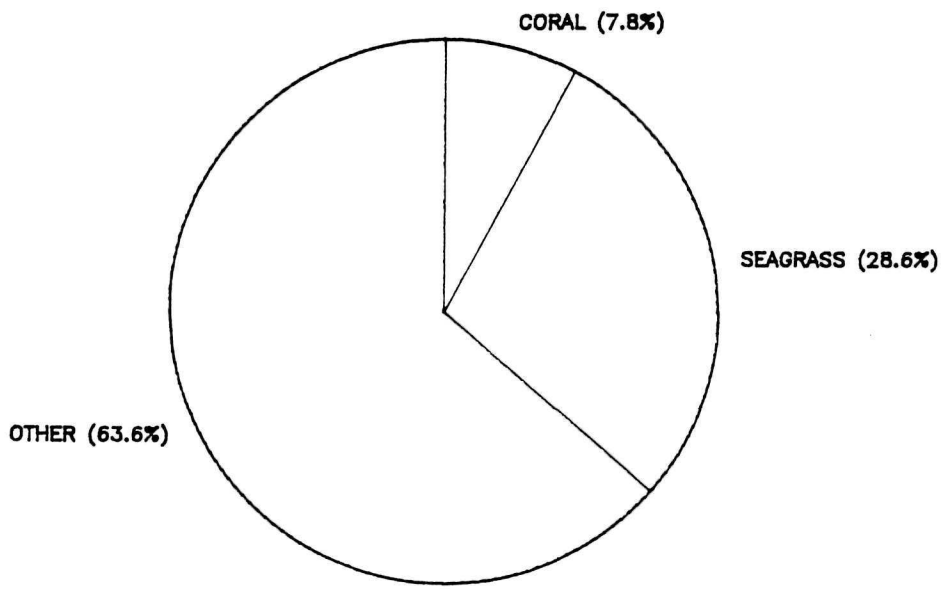


Figure 5a. Bottom type for boats anchored in 6 - 10 meters in northern and western bays of St. John.

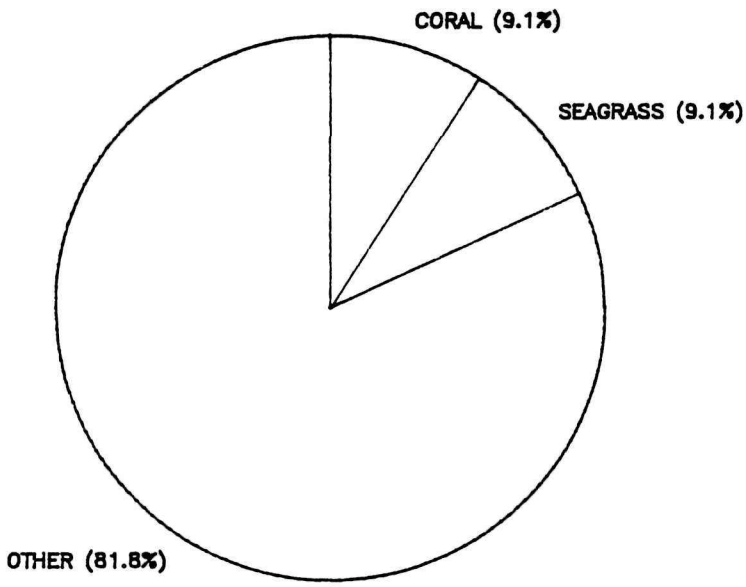


Figure 5c. Bottom type for boats anchored in 11 meters and deeper in northern and western bays of St. John.

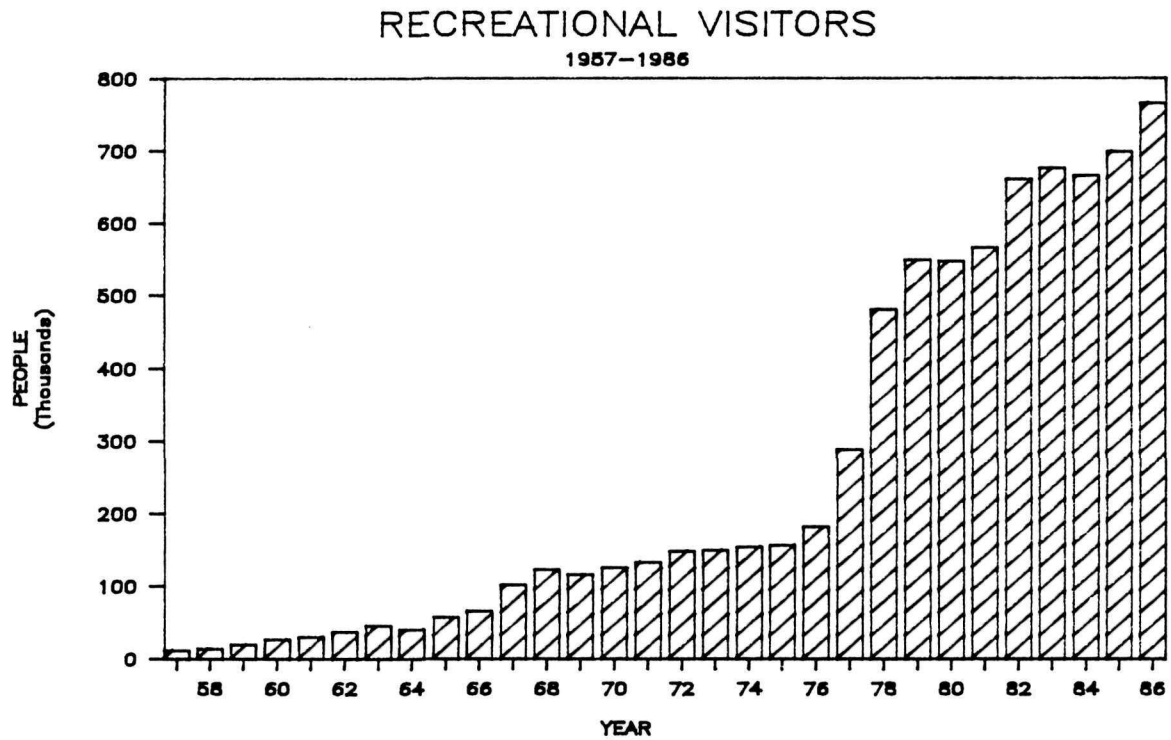


Figure 6. Recreational visitors to VINP from 1957 - 1986.

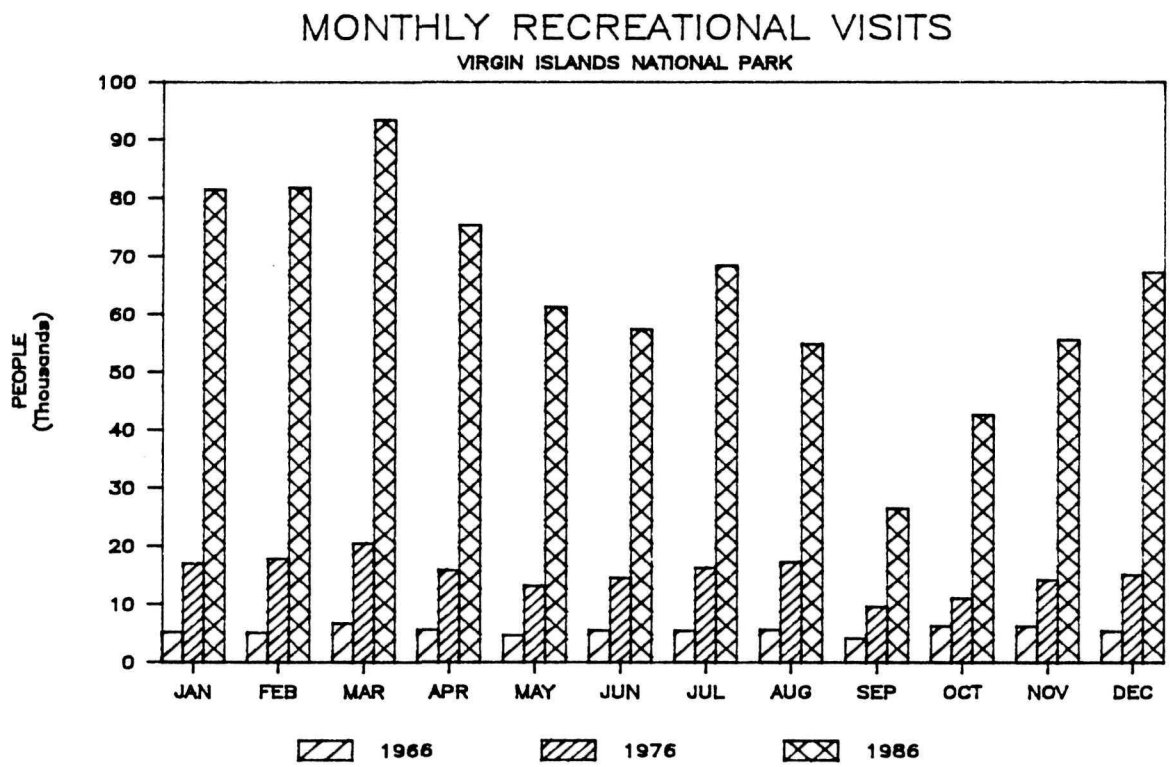


Figure 7. Monthly recreational visits to VINP in 1966, 1976, and 1986.

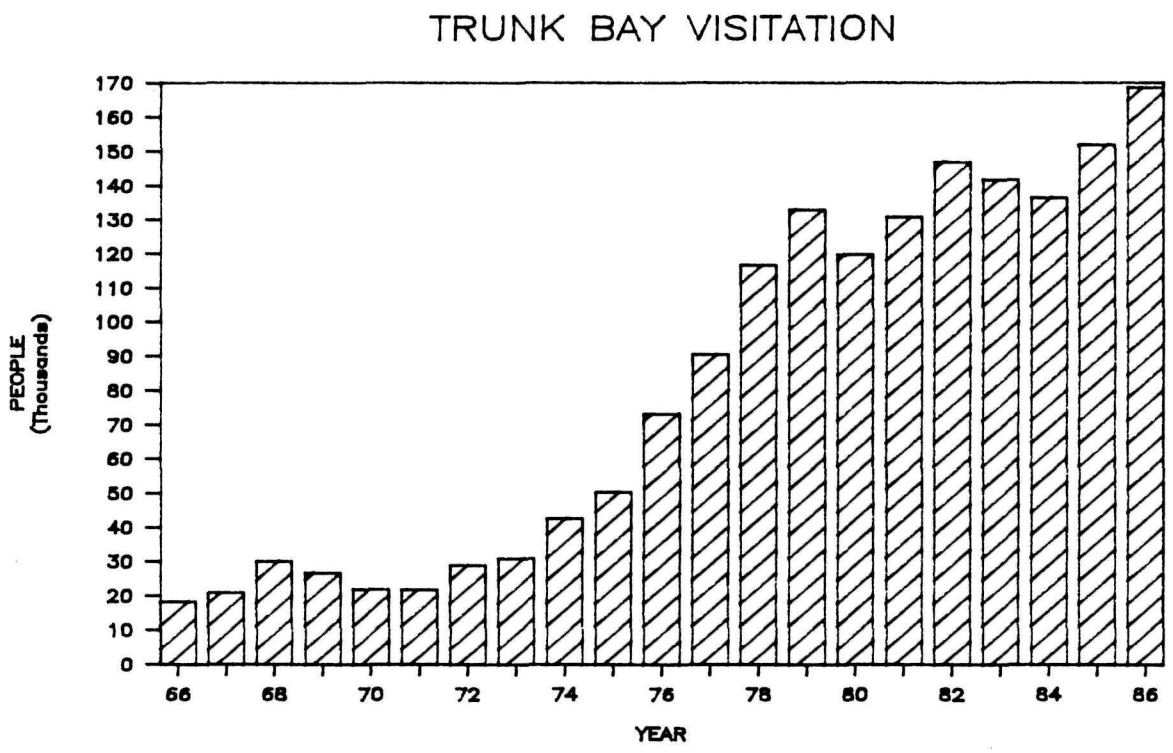


Figure 8. Annual visitation to Trunk Bay beach from 1966 - 1986.

that the trail is "not all within a proper reef, but rather in an area where coral growth occurs directly on hard rock bottom and boulders". He also noted poor conditions for reef growth here because of consistently heavy seas during winter months. While the trail has undoubtedly suffered from extensive use, the amount of deterioration over the years has probably been exaggerated, and it still provides a good snorkeling experience for most visitors.

Boating in Virgin Islands National Park waters The average number of boats per day in park waters, estimated from boat patrol logs and monthly public use reports, ranged from less than 10 in 1966 to about 80 in 1986 (Fig. 9). There was a fairly steady increase beginning in 1977 and a sharp increase between 1981 and 1982. There was some evidence of leveling off between 1982 and 1985, but another marked increase in 1986. Examination of aerial photographs reflects the dramatic increase in boating as well (Table 1).

A closer look at the number of boats in northern and western bays from 1984-1986 (the only years for which there are daily data), shows at least a slight increase for all months in 1986 except October (Fig. 10). Caneel Bay and Francis Bay, the two most heavily used bays in the park, had increases for most months in 1986 (Fig. 11). Examination of the distribution of boats along the northern and western shores of St. John (Fig. 12) indicates the popularity of Caneel and Francis Bays. It should be noted that Caneel Bay here refers to not only Caneel Bay proper, but also Solomon, Honeymoon, and Scott Bays as well, because all of these were combined on boat patrol logs. Consequently, Francis is probably the single most heavily used anchorage in the park.

Mini-cruise ships In addition to the increased calls by large cruise ships such as the "Norway" -- which generally do not anchor in park waters but which discharge passengers who use the park beaches -- there has been an increase in the number of mini-cruise ships which actually anchor in the park, particularly since 1984. The Newport and Nantucket Clippers are 207' long and sometimes anchor in very shallow water as they draw only 9'. Their anchors, which weigh one ton each, have been observed in coral communities and seagrass beds in Maho, Francis, Cinnamon, and Leinster Bays. The skipper of the "Newport Clipper" met with the Research Biologist and Concessions Specialist to discuss park concerns over damage to bottom communities. There is some evidence that single large anchors actually do more damage than several small anchors, at least to seagrass beds. The skipper was very accommodating, and voluntarily began to anchor in less sensitive areas which were far less convenient. Understandably, he expressed concern over all the other boats which are continuing to anchor on coral and seagrass communities.

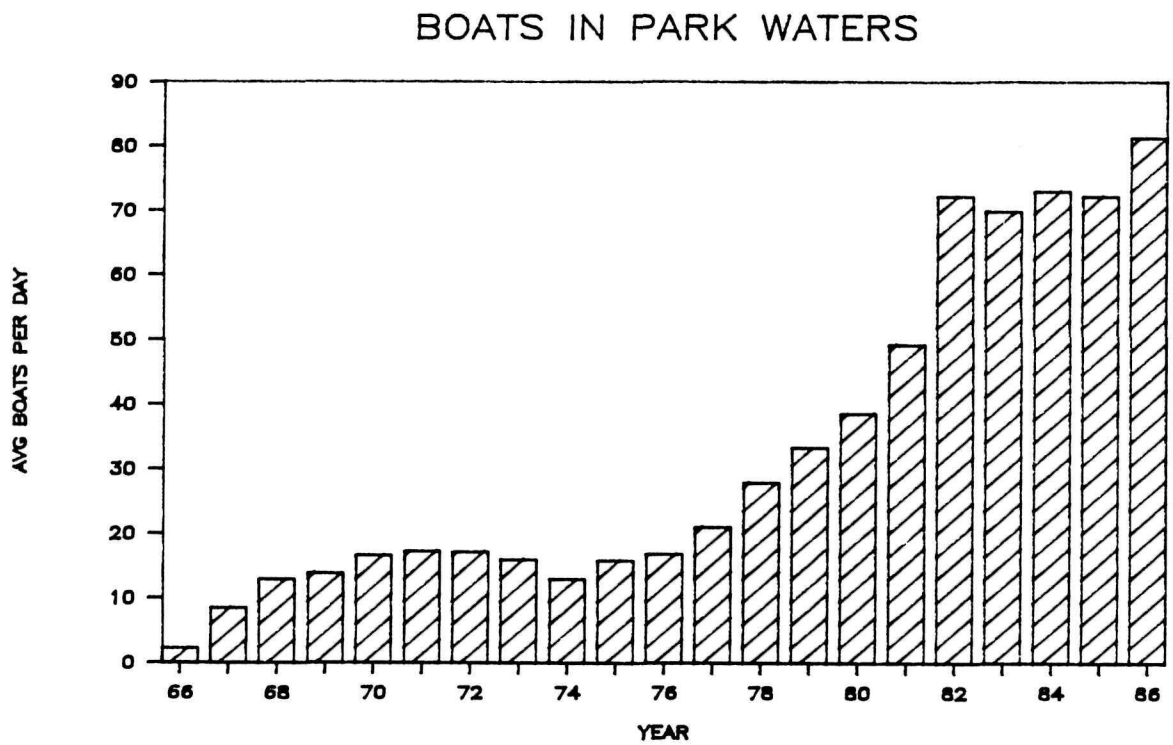


Figure 9. Average number of boats per day in park waters from 1966 - 1986.

Table 1. Boat count made from aerial photographs of St. John

	1946	1965	1971	1978	1983
CANEEL BAY	1	11	4	12	53
CORAL BAY	2	0	3	1	24
SALTPOND BAY	1	0	0	0	3
LAMESHUR BAYS	0	1	1	3	0
CRUZ BAY	2	12	18	32	53
Total	6	24	26	48	133

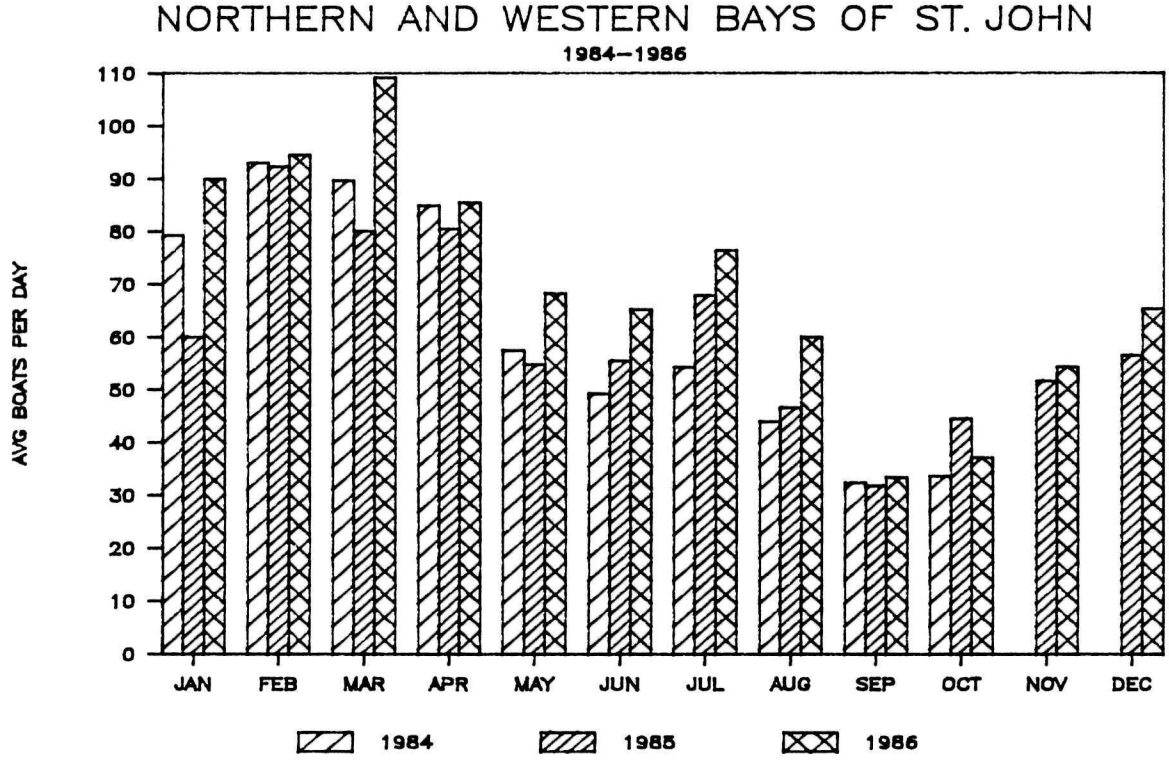


Figure 10. Average number of boats per day in northern and western bays of St. John, 1984 - 1986.

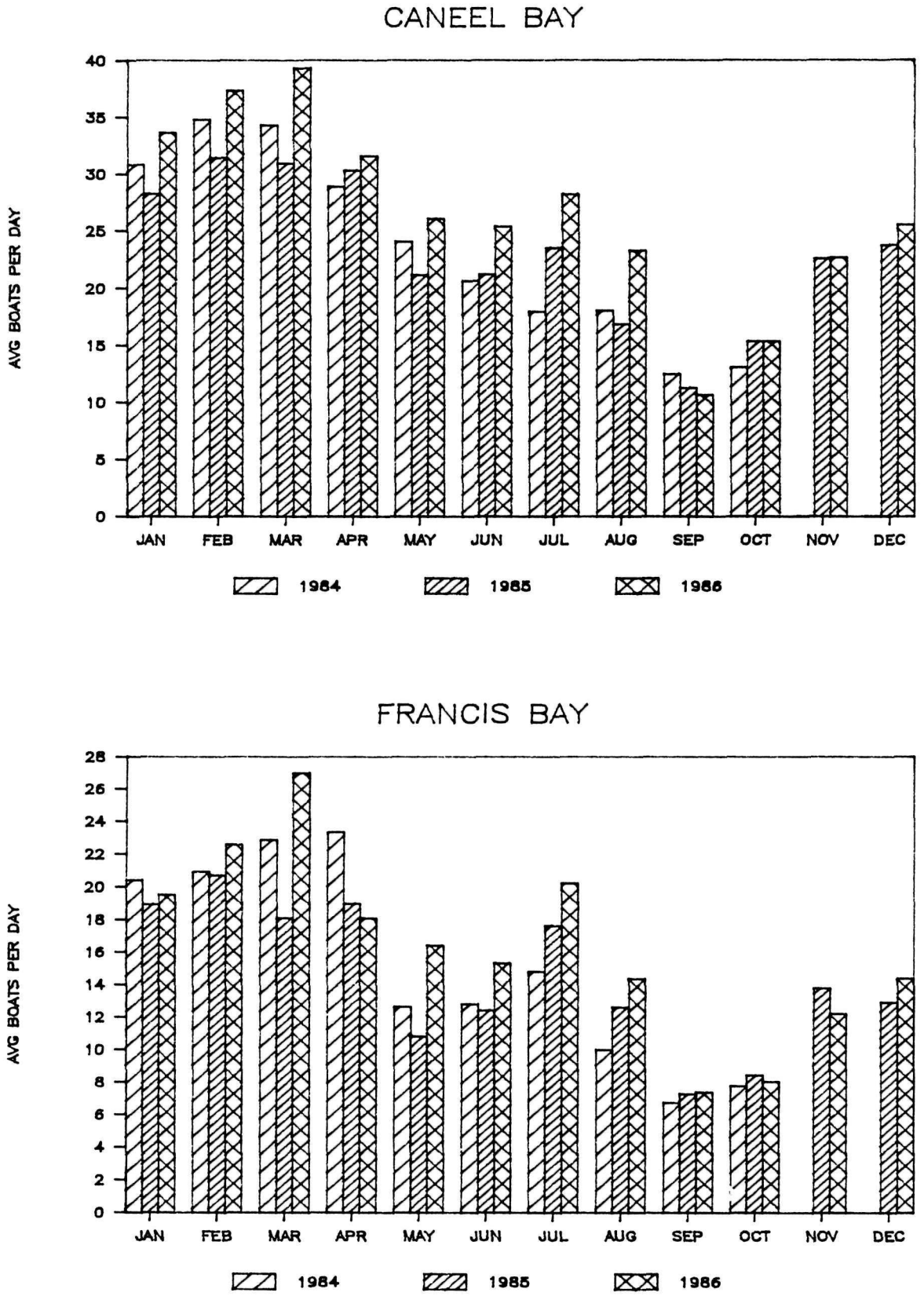


Figure 11. Average number of boats per day in Caneel and Francis Bays, 1984 - 1986.

Incidences of damage and violation of park regulations from NPS logs Based on case incident records, boat patrol logs, and lifeguard logs, the number of incidences of damage to marine ecosystems or possible conflicts among different groups using the resources were very low (Table 2). These numbers are undoubtedly underestimates and reflect inconsistencies in filling out the NPS forms. Unless observations of these violations are recorded more rigorously in the future, the NPS records can not be used to provide data on environmental degradation and conflicts among resource users.

Table 2. Incidences of damage and violations

INCIDENT	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	TOTAL
OIL SPILL & POLLUTION	1	2	2	2	1	5	0	1	4	2	4	24
BOATS ON REEFS	2	5	5	3	3	5	6	0	3	7	7	46
WATER SKIING	3	6	2	1	3	8	3	0	3	4	1	34
ILLEGAL REMOVAL OF CORAL, ETC.	0	0	1	2	4	5	5	3	1	1	1	23
ILLEGAL FISHING	2	5	1	4	1	19	13	7	7	1	3	63
SPEARFISHING	1	3	1	3	1	1	6	2	5	1	2	26
SPEARGUN POSSESSION	1	3	4	4	1	1	2	17	3	4	3	43

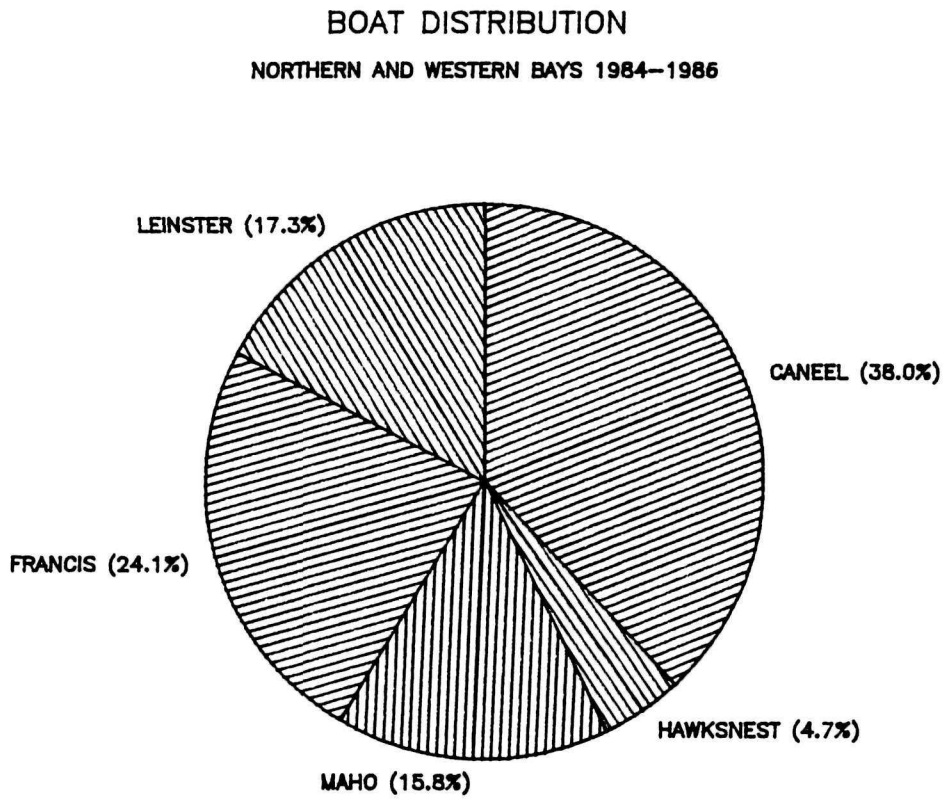


Figure 12. Boat distribution in northern and western bays of St. John.

DISCUSSION

There is a growing recognition of the severity of damage associated with increased recreational uses of marine resources in the Caribbean, and a realization that tourism and resource protection are intrinsically interdependent. However, few systematic reports on trends in recreation or its consequences are available. Johannes' (1975) review of "Pollution and degradation of coral reef communities" does not refer to this type of destruction. Examination of the subjects of papers presented at the International Coral Reef Symposia from 1977 to 1985 shows an increase in the number of presentations on reef conservation and management, with, in some cases, specific references to degradation accompanying increases in tourism and overuse. Tilmant (1987) recently reviewed adverse effects of recreation on coral reefs, citing examples from Australia and Florida. For the British Virgin Islands (BVI), Jackson (1981) stated that, "As far as water-borne tourism is concerned, there are indications that the British Virgin Islands is approaching her physical saturation levels". The fleet of charter boats alone increased 10 times between 1969 and 1980 (Figure 13; Jackson, 1980).

There are numerous examples of severe, localized damage to marine ecosystems attributable to recreation. In a survey of stresses affecting Caribbean reefs, many resource managers and scientists reported damage from anchors (e.g., from cruiseships and dive boats), from boat groundings, and from people walking on reef flats and removing corals as souvenirs (Rogers, 1985). Most respondents felt that the reefs were deteriorating from a variety of causes. Construction of marinas and boatyards to support recreational boating have had serious environmental consequences, particularly in mangrove areas.

Tilmant and Schmahl (1981) attempted to assess visitor damage to patch reefs in Biscayne National Park by counting the number of damaged corals observed in timed visual surveys. Four of the eight study reefs received three or more times the number of visitors as the control reefs. They estimated annual visitation to all of the reefs at about 3600 people. Six boats grounded on the reefs during the 3 year study, damaging large individual coral colonies. Although Tilmant and Schmahl (1981) found a linear correlation between reef use and physical damage, damage from natural causes such as sea swells appeared to mask damage from people swimming and spearfishing near the reefs.

In comparison, within Virgin Islands National Park, adverse effects of recreational activities are far more evident and dramatic. Single boat groundings have frequently caused several square meters of destruction. Four boats hit Windswept Reef in one afternoon. In one week, the underwater snorkeling trail at Trunk Bay receives more visitors than the Biscayne study reefs receive in one year. Perhaps the Biscayne National Park study reefs are deeper than the St. John reefs and therefore less

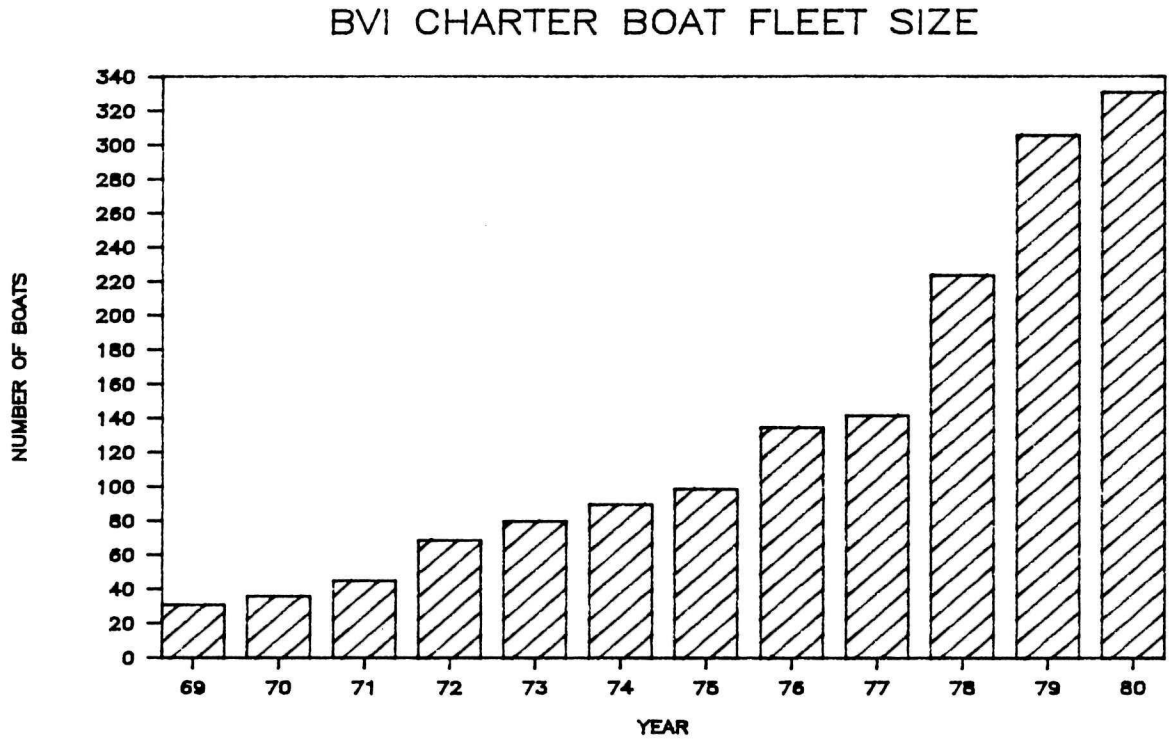


Figure 13. Growth in British Virgin Islands charter boat fleet from 1969 - 1980. (Data from Jackson, 1980).

vulnerable to damage from snorkelers who tend to remain near the surface of the water.

As in the Biscayne National Park study, it was not always possible to differentiate "natural" from visitor damage on the St. John reefs (see Robinson, 1973). Examples of natural damage include 1) scraping away of tissue and sometimes underlying skeletal material by fireworms (Hermodice carunculata), snails (Coralliophila abbreviata), and some fish species, 2) weakening of coral skeletons through action of boring bivalves and other organisms, 3) abrasion from transportation and deposition of sediment particles, and 4) overturning and smashing of corals during heavy seas. Numerous small fractures in the shallowest zones, especially in inaccessible areas, generally indicate damage from heavy swells and waves.

White band disease and other coral diseases have not been directly correlated with human activities although Peters (1984) suggests that injuries to corals from snorkelers and divers and adverse environmental conditions, such as high turbidity and sediment, could increase the frequency of occurrence. White band disease occurs throughout the Caribbean (Rogers, 1985). National Park Service photographs from the early 1970's at Buck Island Reef National Monument, St. Croix, and a diagram appearing in Robinson (1973) indicate presence of white band disease on Virgin Islands reefs at that time. It is not known if the dramatic increase in visitation to Caribbean coral reef areas and damage resulting from recreational activities have been accompanied by increases in coral diseases.

Sometimes damage is clearly the result of recreational activities. On a number of occasions, we saw dinghies go up on the Hawksnest patch reefs and larger boats hit Windswept. We also observed blue or red anti-fouling bottom paint on coral colonies during our surveys, clearly indicating destruction by boats striking or grounding on the reefs. Divers and snorkelers damage corals by bumping into them or standing on them, and by overturning colonies to reach lobsters. Isolated, broken branches a few feet below the surface of the water usually are a sign of careless or inexperienced snorkelers. Collection of hard corals and sea fans as souvenirs, and black corals in deeper water for making jewelry also takes place.

Residents and tourists who walk on shallow reef flats do considerable damage in some areas. A particularly glaring example is Buccoo Reef, Tobago. In a 1986 letter to the Director of the Conservation Monitoring Centre, International Union for the Conservation of Nature and Natural Resources, the President of the Crusoe Reef Society wrote: "Buccoo Reef has been under severe pressure over the last 20 years. Storms have uprooted large sections of coral and disease has further killed off complete colonies. Man, with apparent ignorance, has put the final touch, plowing areas with different types of anchors, carving channels with the indiscriminate use of outboard engines

and with the protection of various footwear, trampled whatever was left into the sand. Approximately 95% of the shallow reef area has been destroyed. The remaining 5% will disappear within the next two years."

Recently, concern over the enormous quantity of plastic entering the ocean's waters from many sources, including pleasure boats, has increased (Laist, 1987). Fish and birds ingest plastic particles and die. Plastic bags wrap around corals and suffocate the tissues underneath. Reefs in Haulover Bay, St. John, receive large amounts of plastic and other trash from passing boats and probably from Road Town Harbor, Tortola. Large plastic bags full of trash from cruise ships have been found in USVI waters.

In 1977, Gladfelter et al. (1977) assessed human influences at the Buck Island Reef National Monument off St. Croix by examining disturbance from mooring chains and from boats striking the reef. Surprisingly, they found a higher percentage of live coral in areas swept by the chains, concluding that the chains reduced cover by benthic algae which compete with corals for space. One would expect that abrasion by these chains would kill at least small coral colonies. (The authors do not provide information on size or number of corals in their study plots.) At least in the seagrass beds on St. John, anchor chains scour out large areas of the bottom. Scars from boat propellers, and presumably from anchors as well, can take decades to recover (Zieman, 1976).

In a recent VIRMC study, Williams (1987) noted an apparent decrease in the extent of the seagrass beds in Francis and Maho Bays over the last 30 years judging from a series of aerial photographs and comparison of recent benthic maps with a map from 1959 (Kumpf and Randall, 1961). Although the relatively large population of green sea turtles (an estimated 50 individuals) which grazes on these grasses may be stressing them, much of the damage observed in these bays and the general deterioration of the grasses are at least partially attributable to anchoring. As noted above, Francis Bay is probably the most popular anchorage in Virgin Islands National Park. Williams (1987) recommended prohibiting anchoring in as large an area as feasible in Francis and Maho Bays. The present study showed that 46% of the boats surveyed in park waters were damaging seagrass or coral bottoms.

To date, VINP has been spared the extensive damage associated with anchoring of commercial boats such as the shrimp boats in Dry Tortugas, Florida (Davis, 1977) and dramatic groundings of large ships such as the "Wellwood" which damaged an estimated 7.53 ha (75,275 m^2) of coral reef bottom off the Florida Keys (Jaap, 1984). However, the amount of damage to park resources currently associated with mini-cruise ships and smaller boats is unacceptable and will only increase unless some management actions are taken.

Some positive steps have been taken:

1. Recent research by the Virgin Islands Resource Management Cooperative has focused attention on the degradation of marine ecosystems in Virgin Islands National Park, and the park's Research and Resources Management staff has developed a Shoreline Management Plan in an effort to balance protection of the park's resources with increased pressure from visitors. Installation of moorings in Francis Bay and other critical, sensitive near shore areas is a key element in this plan. Benthic maps produced in 1984 for the bays in VINP have been an especially good basis for the plan (Beets et al., 1986). As described above, marker buoys are helping to reduce damage to vulnerable reefs. Also, small portions of the seagrass beds in Francis and Maho Bays have been marked off as "no anchoring zones".

2. Wayside exhibits and brochures are being developed to educate visitors as to the fragility of reef areas within VINP. Interpretive programs are focusing more and more on marine resource degradation and possible solutions. NPS is producing a short educational film for cruise ship passengers.

3. The British Virgin Islands National Parks Trust cooperated with dive tour operators to establish moorings at the Wreck of the Rhone Marine Park to decrease anchor damage at this very popular dive site near Salt Island.

4. Looe Key National Marine Sanctuary in Florida has a very effective mooring system (see Halas, 1985), and Billy Causey, the Sanctuary Manager, wrote that "the installation of the buoys has been the most beneficial effort that we could have undertaken to protect our reefs". Similar moorings are being considered for VINP. Educational brochures have been especially helpful.

Recommendations for monitoring and documentation of trends in recreational uses of marine resources

The following recommendations may be useful to people responsible for managing marine protected areas.

1. Record number of visitors, number of boats, and patterns of resource use.

2. Record number of new breaks of branching coral colonies on shallow, heavily visited reefs.

3. Record number of conspicuous anchor scars in seagrass beds.

4. At a minimum, record bottom communities in popular anchorages. When feasible, produce benthic maps.

5. Take sequential underwater photographs from the same locations to document changes in reef structure, e.g., along underwater snorkeling trails.

6. Use aerial photographs to discern large scale changes over time (especially useful for seagrass beds).

7. In some instances it may be feasible to establish transects of seagrass beds and reefs to provide quantitative information for documenting trends in density and amounts of living cover.

Specific recommendations for Virgin Islands National Park

1. Implement the new Shoreline Management Plan; consider further zoning of park waters for certain activities (e.g., fishing) to avoid conflicts among resource users (see Kelleher, 1985 on zoning for Great Barrier Reef, Australia; see Putney, 1987, on resource users in VINP).

2. Consider minimum depth or minimum distance from shore requirements for anchoring in areas where anchoring is allowed.

3. Increase awareness of park regulations and environmental concerns within the park through a series of seminars at the new Virgin Islands Biosphere Reserve Center, through production of more informative brochures for visitors and through further development of interpretive programs (snorkel trips, evening programs, shorewalks); brochures could include information on locations of particularly vulnerable reefs for distribution to charter boat companies and others.

4. Continue long-term monitoring of selected reefs and initiate monitoring of other reefs as necessary; use underwater video cameras to document conditions at the Trunk Bay underwater trail and other key reef sites.

5. Monitor recovery of anchor scars in seagrass beds.

6. Establish a water quality monitoring program in VINP to determine if sewage, oil, and fuel from boats are causing deterioration of water quality in park waters.

7. Consider excluding mini-cruise ships from park waters, or limit them to one or two bays and require that they establish and use moorings.

8. Work toward closer cooperation between the Division of Research and Resources Management and rangers and interpreters to ensure accuracy of information presented to visitors; devise new forms which will be more useful in documenting environmental damage.

Conclusion

The National Park Service has the responsibility and the obligation to manage Virgin Islands National Park not only as a national park but as a biosphere reserve. As a biosphere reserve, VINP should serve as a protected area for comparison with unprotected areas to allow assessment of environmental trends. Currently, marine resources of Virgin Islands National Park and Biosphere Reserve are suffering unacceptable degradation from development and tourism. More effective management measures are urgently needed to increase protection of these resources.

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APPENDIX I

WINDSWEPT REEF
Boats that struck or grounded
on reef from Jun 1985-Jan 1987

DATE	TIME	BOAT TYPE	BOAT STRUCK REEF	BOAT GROUNDED ON REEF
JUN-23-85	1400	POWER BOAT (16')	X	
JUL-14-85	0915	POWER BOAT (22')		X
JUL-26-85	0600	POWER BOAT (25')	X	
JUL-26-85	1500	POWER BOAT (16')	X	
JUL-27-85	1820	POWER BOAT (40')	X	
JUL-31-85	1700	SAIL BOAT (36')	X	
AUG-04-85	0900	POWER BOAT (50')	X	
AUG-04-85	1700	POWER BOAT (25')	X	
AUG-18-85	1700	POWER BOAT (20')		X
SEP-02-85	1320	POWER BOAT (18')	X	
SEP-04-85	1530	POWER BOAT (14')	X	
SEP-04-85	1615	SAIL BOAT (26')	X	
SEP-08-85	0945	POWER BOAT (14')	X	
SEP-08-85	1517	SAIL BOAT (36')	X	
DEC-08-85	1100	POWER BOAT (26')	X	
DEC-08-85	1535	POWER BOAT (22')	X	
DEC-08-85	1630	SAIL BOAT (28')	X	
DEC-08-85	1702	SAIL BOAT (45')	X	
DEC-24-85	1930	SAIL BOAT (36')		X
FEB-21-86	1900	POWER BOAT (18')	X	
APR-30-86	2030	POWER BOAT (?)	X	
MAY-04-86	1040	POWER BOAT (12')	X	
MAY-04-86	1605	POWER BOAT (10')	X	
NOV-05-86	1530	POWER BOAT (10')	X	
JAN-18-87	2030	SAIL BOAT (30')	X	