Coastal region and small island papers 1

MANAGING BEACH RESOURCES IN THE SMALLER CARIBBEAN ISLANDS

Workshop papers

Edited by Gillian Cambers

UNESCO

Sea Grant
Universidad de Puerto Rico

IOCARIBE

Cambers, G. (ed.), 1977. Managing Beach Resources in the Smaller Caribbean Islands. Papers presented at a UNESCO - University of Puerto Rico Workshop, 21-25 October 1996, Mayagüez, Puerto Rico. Coastal region and small island papers, No.1, UPR/SGCP-UNESCO, Mayagüez, 269 pp.

Note: The workshop report was published as:

UNESCO, 1997. *Integrated Framework for the Management of Beach Resources within the Smaller Caribbean Islands.* Report from a UNESCO - University of Puerto Rico Workshop, 21-25 October 1996, Mayagüez, Puerto Rico. CSI info 1, UNESCO, Paris, 31pp.

Published in 1997 by the
University of Puerto Rico Sea Grant College Program
P.O. Box 5000, Mayagüez, Puerto Rico 00681-5000
and the United Nations Educational, Scientific and Cultural Organization,
7, place de Fontenoy, 75732 Paris 07 SP, France

Printed by UPR Sea Grant Printers
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Printed in Puerto Rico

PREFACE

This volume contains the papers presented at a workshop entitled 'Integrated Framework for the Management of Beach Resources within the Smaller Caribbean Islands' which was held at the University of Puerto Rico, Mayagüez Campus, 21-25 October 1996. The workshop was organized on the Coastal Regions and Small Islands (CSI) platform by the University of Puerto Rico and its Sea Grant College Program, and co-sponsored by UNESCO through the Intergovernmental Oceanographic Commission and CSI.

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FOREWARD

As in other parts of the world, beaches in the Caribbean are special places for recreation, for scenery and for revitalizing the soul. Moreover, in the Caribbean Islands, beaches are the economic "lifeblood" of the countries. Tourism is the main industry in many of these islands, and although some islands are trying to diversify their product to include nature, historical and cultural tourism, the vistas of waving palm trees, white sand beaches and aquamarine seas remain at the forefront of the tourist brochures.

Yet these very beaches are under threat and have been for decades. In every island one can see evidence of coastal erosion, walls replacing sand beaches, buildings replacing natural coastal vegetation, and sometimes muddy coloured seas. And everywhere there is evidence of the proliferation of houses, condominiums, hotels, restaurants and roads either on or behind the beach.

1995, the second most active year for hurricanes since records began, was a "wake-up call" for many of the Caribbean Islands. Within a three week period, one tropical storm and two hurricanes moved through the Eastern Caribbean Islands wreaking a path of damage and destruction to man-made infrastructure and the natural environment. Some islands which had not experienced a hurricane for more than thirty years, and whose younger generations had no experience of what was to come, found themselves directly in the path of a category four hurricane. Predictions lead us to believe that this may only be a foretaste of the future.

Against this background, work has been ongoing for more than a decade to help the islands manage their beach resources within an overall framework of integrated coastal management. A regional programme "Coast and Beach Stability in the Lesser Antilles" (COSALC) was started by UNESCO in 1985, in response to a request from the islands for help with the problems they were experiencing with coastal erosion and its effects on the vital tourist industry. Since 1994, COSALC has been jointly sponsored by the University of Puerto Rico Sea Grant College Program (UPR/SGCP).

Within the framework of this programme, environmentalists and physical planners, scientists, regional agencies and non government organizations (NGO's), hotel owners and sand miners, from the Eastern Caribbean Islands, met in Mayaguez, Puerto Rico between 21st and the 25th October, 1996, to discuss the problems facing their islands' beaches, to exchange information on solutions and case studies and to determine what needs to be done in the area of beach management. This meeting was sponsored by UNESCO within its Coastal Region and Small Island endeavor (CSI), the Intergovernmental Oceanographic Commission of UNESCO and the UPR/SGCP.

The papers presented at the meeting are contained in this volume. They cover four main management areas: coastal erosion, beach sand mining, traditional and cultural beach practices, beaches as a tourism resource. They represent the full range of beach management issues in the islands and provide an insight into current ideas and approaches to solutions.

It is hoped that this volume will be useful to coastal resource users and managers throughout the Caribbean as well as to small island developing states in other oceans of the world.

Gillian Cambers,
University of Puerto Rico,
30th December, 1996.

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ENVIRONMENTAL MONITORING AS A PLANNING TOOL: FACT OR FICTION

Gillian Cambers, Coast and Beach Stability in the Lesser Antilles (COSALC),
University of Puerto Rico Sea Grant College Program

ABSTRACT

The paper examines environmental monitoring in general, and the measurement of beach changes in particular, within the concept of integrated development planning. A database on beach changes in eleven Eastern Caribbean Islands, which covers the period 1985 - 1995, is described. In most of the eleven islands, the database is beginning to be applied to issues such as the design of sea defences, the selection of beaches for mining and in the planning and review of new coastal developments. In one island, Anguilla, the database has been applied to the preparation of coastal development setback guidelines which will ensure that new development does not cause beach erosion, and likewise that the new projects are not impacted by beach erosion. Setbacks have been calculated for individual beaches using the beach change database, the likely effects of a major hurricane and other geographical, morphological and planning factors. These setbacks are currently being implemented in Anguilla. It is hoped that these guidelines can be applied to other islands in the region. Environmental monitoring is therefore perceived to be an important planning tool.

INTRODUCTION

The natural environment in which we live is undergoing constant change. As trees grow, the natural succession changes and forests mature; as coral reefs grow towards the surface of the ocean, shallow lagoons are formed where seagrass and other flora and fauna flourish; new land is formed as mangroves grow and mature. Many of these changes take place slowly, but with some systems dramatic changes occur in a matter of hours, for instance a major winter swell event may result in severe beach erosion over night. Beaches are one of the fastest changing natural environments.

Man is continually interacting with the natural environment in which he lives and in many cases he is trying to change it as for instance when forests are cut down or land is reclaimed from the sea. Sustainable development hinges on this interaction between man and his natural environment and in order to achieve the goal of sustainability we must know about the natural changes that are taking place in our environment as well as those changes caused by ourselves.

But it is not enough to know about the manner in which the environment is changing. This information must then be used within the development planning agenda so as to ensure that future development is sustainable.

Whilst monitoring of various coastal resources has been ongoing in the Caribbean Islands for the past decades, much of this monitoring has been of a spasmodic nature and only rarely has it been applied to and used within the development planning process. It is the purpose of this paper to describe one monitoring programme relating to beaches and to show how only after a considerable number of years of data collection has the information been applied to the development planning process.

THE IMPORTANCE OF BEACHES TO THE CARIBBEAN ISLANDS

Beaches:

- are an essential part of the tourism product;
- provide an important recreational resource for tourists and local residents;
- protect coastal lands from wave action, especially during hurricanes;
- provide habitats for animals and nesting sites for sea turtles;
- provide fish landing sites and areas for beaching boats;
- are a source of fine aggregate for construction in some islands;
- are an aesthetically pleasing part of the environment.

As a result of waves, tides and currents, beaches change on an hourly, daily, seasonal and long-term basis. Human actions, such as the building of seawalls and groynes also influence these changes, In recent decades beach erosion has become a major problem and concern to the Caribbean Island nations. This concern is largely due to the fact that most people live near the coasts so most islands' infrastructure is located near to the beach, in addition, beaches are vital to the tourism industry.

While some beaches in the Caribbean are accreting, the overall trend on the islands is towards beach erosion as a response to hurricanes, winter swells, beach sand mining and pollution. The change in building material from wood to concrete, has contributed to massive losses of beach sand, as in most islands construction sand has traditionally been obtained as a 'free resource' from the beach. Pollution - including sedimentation - may cause deterioration and destruction of the coral reefs. In a healthy condition, reefs protect beaches from wave action and also represent a major source of beach sand. Beach erosion rates vary considerably, rates as high as 5 metres per year have been recorded on some beaches in the Eastern Caribbean.

Beaches may get smaller (erosion) or larger (accretion). It is useful to view erosion and accretion as changes in direction, erosion taking place when the beach form moves landwards, and accretion when the beach form moves seawards. On an undeveloped coastline, where say a beach is backed by a palm plantation, it is often very difficult to determine trends, for erosion such as may occur during a storm is usually followed by a period of accretion when the beach re-builds. Thus to a casual observer, there may appear to be no overall change over a period of months. It is only by careful measurement that changes and trends can be determined.

MONITORING OF BEACH CHANGES

A programme entitled "Coast and Beach Stability in the Lesser Antilles (COSALC)", was started by UNESCO (United Nations Educational Scientific & Cultural Organization) in 1985, following a request from the smaller islands of the Eastern Caribbean for assistance with the serious problems they were facing relating to beach erosion. They were particularly concerned about the impacts of the erosion on the vital tourist industries. COSALC was initially established within UNESCO's COMAR (COastal MARine) project. Since January 1996, this has been replaced by UNESCO's Coastal Regions and Small Islands Unit (CSI). In 1994 a memorandum of understanding was signed by UNESCO and the University of Puerto Rico Sea Grant College Program (UPR-SGCP) whereby UPR-SGCP agreed to provide the facilities for a coordination centre for COSALC.

The overall objective of COSALC is to develop the in-country capability within the islands of the Caribbean to measure, assess and manage their beach resources within an overall framework of integrated coastal management.

A network approach has been adopted such that within the overall regional objectives, specific assistance can be provided to each island depending on their capabilities and needs.

Ten island states/territories belong to COSALC, these are as follows :

Anguilla,
Antigua and Barbuda,
British Virgin Islands,
Dominica,
Grenada,
Montserrat,
St. Kitts-Nevis,
St. Lucia,
St. Vincent & the Grenadines.
Turks & Caicos Islands.

Emphasis has been placed on in-country training of technicians from government agencies and non government organizations (NGOs) to measure beach changes and coastal processes using standardized techniques. The techniques developed are simple, easy to use and require minimum equipment. They can be successfully conducted by a high school graduate, provided the necessary training is provided. They consist of establishing, and measuring on a regular basis, beach profiles (or cross sections) at certain key beaches in each island. The beaches selected consist of control sites as well as locations heavily developed for tourism, or where activities such as sand mining have or are taking place. The equipment consists of Abney levels, ranging poles, tape measure and camera. The data are analysed using specially designed software based on Lotus 123 spreadsheets. Once minimum databases have been established the monitoring data are used to develop solutions to specific beach management problems. Education and awareness activities are also areas of particular emphasis in the COSALC programme.

Integrated Coastal Management

Beaches are but one part of the coastal system which extends from the watershed to beyond the coral reefs. It is first necessary to look at the system in its entirety through a mechanism such as integrated coastal management (ICM). Many definitions exist for ICM, the one used in this paper was developed at an international workshop in Charleston, South Carolina, (CAMPNET, 1989).

> *"Integrated coastal management is a dynamic process in which a co-ordinated strategy is developed and implemented for the allocation of environmental, socio-cultural and institutional resources to achieve the conservation and sustainable multiple use of the coastal zone."*

This definition contains many different concepts, but there are four that should be emphasized:

a) ICM involves a dynamic process, in other words it involves a flexible approach that changes with time;

b) A coordinated strategy is developed, this would include a coordinated programme or plan involving several different groups and agencies, the key word is coordination;

c) The balancing of natural and human resources is key to the understanding of ICM;

d) The goal of ICM is to conserve and use the resources of the coastal zone, these two concepts, preservation and use, which are understood in the term management, may sometimes conflict.

These ideas have been further developed in a series of case studies, (Cambers, 1992). The COSALC programme, while concentrating on one part of the coastal system, beaches, attempts to utilise the principles of ICM. For instance, it attempts to bring together different government agencies, such as planning, environment and public works, along with non government organizations (NGOs) and coastal communities and other stakeholders such as the tourism sector, to measure beach changes and then to use that information in the search for solutions.

One of the most difficult aspects of ICM is referred to in d) above - the use and conservation of coastal resources, this often results in conflict. For instance, is it possible to build a beach hotel and still conserve the beach. In theory the answer is yes, but so often in practice we find that beach erosion follows the hotel construction and this is in turn is followed by a combination of seawalls, groynes and other measures and possibly further erosion. The reason for this is that often when a beach hotel is constructed no allowance is made for the natural changes that happen to a beach.

The route to full ICM may take decades. ICM is a very complex series of concepts, which by its very nature necessitates a multi-disciplinary approach. There are times when the whole series of concepts involved in ICM are "just too big to deal with" either by a developing country or an aid agency who often prefer a project approach. It is thus important to understand the steps involved in ICM and to develop flexible programmes which will respond to the individual needs of the Caribbean countries which are all at different stages along the path to ICM.

In a discussion on the status of ICM in three Caribbean countries, Barbados, British Virgin Islands and St. Kitts, it was suggested that institutional strengthening (including training) is the most important component of ICM and the area requiring most assistance at the present time, (Cambers, 1993).

A country may develop an ICM programme as a response to a serious coastal problem such as declining fish stocks or beach erosion. They may not set out to develop an ICM programme, rather they may aim to solve the particular problem, but in the process of doing so, they develop an approach to ICM. This was the case with Barbados, who set out to solve a serious beach erosion problem, but are now developing an ICM programme. Thus, although many countries in the Eastern Caribbean are beginning to develop ICM programmes, they are not necessarily called by that name.

RESULTS OF THE BEACH MONITORING PROGRAMME

The main results have been in the areas of institutional strengthening, research, education and awareness. The specific areas are itemized below:

(a) Persons from government agencies, NGOs, and in some cases high school students, have been trained in the field measurement of beaches as well as in the theory behind beach changes. This has been achieved in the main through on-the-job training and small workshops.

(b) Beach change databases are maintained in each island, usually in an environmental agency. These vary in length from two to eight years. Technical reports are produced annually which present and interpret the beach changes. A regional database of all the islands' beach changes and wave records is maintained at the UPR-SGCP. The data are providing considerable insight into the nature of beach changes over the last decade in the islands, there appears to be an overall background level of erosion in all the islands, around 0.3 m/yr (1 foot/year). Extreme events, in particular Hurricane Hugo in 1989 and Hurricane Luis in 1995, have caused major beach changes which appear to be irreversible.

(c) The beach change information is beginning to be used in the planning process, particularly in the review of new coastal development applications, selection of which beaches (if any) should be mined, in the design of sea defences and environmental impacts assessments (EIAs). However, there is still a long way to go before the databases are fully incorporated into the decision making process in every island.

(d) Efforts are ongoing to ensure that the beach change databases are made user-friendly and as such available to all coastal stakeholders, such as coastal communities and beachfront hotel owners, so that key interest groups and the general public will also become more aware of the importance of their beaches and the changes they are undergoing.

Coastal Development Setbacks

Another way in which the beach change databases are being applied to the islands' coastal problems is through the development of coastal development setbacks. Coastal setback provisions ensure that development is prohibited in a protected zone adjacent to the water's edge. A coastal development setback may be defined as :

> *a prescribed distance from a coastal feature (such as the line of permanent vegetation) within which all or certain types of development are prohibited.*

Coastal development setbacks have several functions :

- they provide buffer zones between the ocean and coastal infrastructure, within which the beach zone may expand or contract naturally without the need for seawalls and other structures, which may imperil an entire beach system. Thus in this sense they may actually reduce beach erosion;
- they reduce damage to beachfront property during high wave events e.g. hurricanes;
- they provide improved vistas and access along the beach;
- they provide privacy for the occupiers of coastal property and also for persons enjoying the beach as a recreational resource.

Most Caribbean Islands have one fixed setback for all their beaches, e.g. the setback for new development in Barbados is 30 m (100 feet) from high tide mark, in the British Virgin Islands it is 15 m (50 feet) from high tide mark. These setback distances are rather low, particularly if there is a major event such as a tropical storm or hurricane. In Nevis the setbacks are more generous, on the other hand, this has caused some local resistance because a lot of valuable land is therefore tied up and unavailable for development.

Most Caribbean Islands use high water mark as the baseline for measurement, however, there are several problems with the use of this criterion. The position of the high tide mark varies from day to day, sometimes its position can change by more than 10 m from one day to the next, particularly if there is a winter swell event. It is also somewhat subjective unless defined by an accurate vertical height, which is not the case in the Caribbean Islands. Thus developers and planners may differ in the interpretation of high tide mark as a baseline.

Since there is a need for further development in the coastal zone in the interests of the islands' economic well-being, setback policies must be designed to ensure that new development is sustainable. The concept of variable setbacks, which make allowances for differences in the behaviour, characteristics, erosional history and use of individual beaches, can best fulfill this function in the Caribbean Islands.

Anguilla was severely impacted by Hurricane Luis in September, 1995. There was considerable damage to coastal infrastructure due to the high waves and storm surge (Cambers, 1996a). Following the hurricane new coastal development setbacks were developed for the beachfront lands, which utilized the concept of specific setbacks for each beach (Cambers, 1996b). The following parameters were included in the setback calculation:

- Historical changes in the coastline position using the aerial photographs dating back to the 1960's when available;
- Recent beach changes using the beach monitoring data;
- Changes in the position of the dune line/coastline, such as those which occurred during Hurricane Luis, a category 4 hurricane;
- Changes in coastline position likely to occur as a result of the predicted rise in sea level;
- Offshore features and changes;
- Coastal geomorphological features such as exposed beachrock and anthropogenic factors such as dune mining;
- Planning considerations such as lot size, national park designations.

The vegetation line was used as the baseline for measurement, this is a more stable line than the high water mark. A map was developed for Anguilla showing the specific setback for each beach, these new setbacks are presently being implemented. However, it must be recognized that it is one matter for planners to prescribe setbacks, but in order for them to be successful, groups such as architects, draftsmen, developers and the general public, must be shown the rationale and the need for such planning tools. As with other facets of ICM, the need for education, participation and communication is of paramount importance.

One of the parameters used in the setback calculation is the change likely to occur in the dune line/coastline during a major (category 4) hurricane. Using the COSALC beach change database, it is now possible to make some empirical predictions about such a change.

Since 1985, when monitoring began in some islands, the Eastern Caribbean Islands have been impacted by two category 4 hurricanes, Hurricane Hugo in 1989 and Hurricane Luis in 1995. Data exists for seven islands, showing the changes that occurred during these hurricanes and the amount of recovery after the event (Cambers, 1996c). The most serious impact was the retreat of the dune line or land edge during these hurricanes. Thus although in many cases, the beaches re-built after the hurricane, their position was further inland. This retreat of the dune edge or land edge on a lowland coast is regarded as a permanent change.

Table 1 shows the retreat of the land/dune edge for six islands after Hurricane Luis and the distance from the island to the centre of the hurricane.

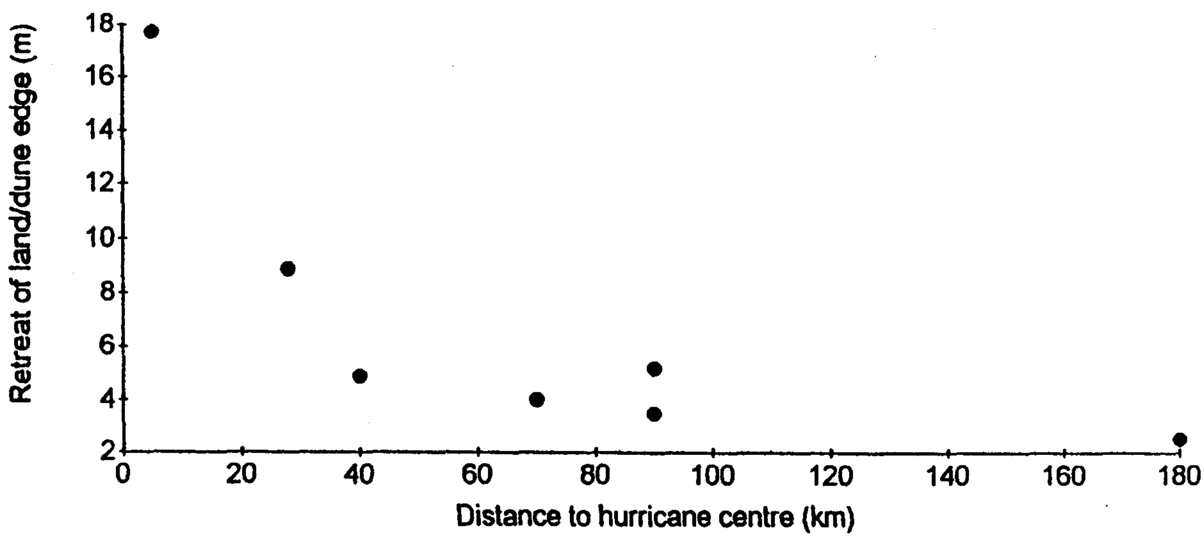
Table 1 Coastline Changes and Proximity to the Centre of Hurricane Luis

Island	Distance to the Centre of Hurricane Luis (km)	Average Retreat of land/dune edge (m)
Anguilla	28	8.9
Barbuda	5	17.5
Antigua	40	4.9
St. Kitts	70	4.0
Nevis	90	5.2
Montserrat	90	3.5
Dominica	180	2.5

As expected, the closer to the hurricane, the greater the land/dune (here referred to as coastline) retreat. The hurricane centre passed within 5 km of Barbuda, here the coastline retreat was greatest, an average of 18 m. Anguilla, which lay 30 km from the hurricane centre, also experienced serious coastline retreat, an average of 9 m, this was, however, less than for Barbuda. While Dominica, which was 180 km from the hurricane centre experienced an average coastline retreat of 3 m. While this was significantly less than some of the other islands closer to the hurricane centre, it still represents significant erosion.

Figure 1 shows the data plotted and there appeared to be a threshold around 40 km from the storm centre: closer than 40 km to the hurricane centre, the erosion rate increased exponentially.

Figure 1 Relationship Between Coastline Retreat and Proximity to the Hurricane Centre (Hurricane Luis, 1995)



In the light of hurricane predictions for the next twenty years, it is likely that each of the Eastern Caribbean Islands will be impacted by a major hurricane (category 3 or higher) over this period. This does not mean that a hurricane centre has to pass directly over the island, as can be seen from the above data, significant erosion occurs when a major hurricane passes within 180 km of an island. Thus it is essential to use the databases to build hurricane vulnerability into coastal development setbacks in the islands, so that new development will not be a cause of beach erosion or be impacted by beach erosion.

CONCLUSIONS

Environmental monitoring is a very time consuming and often costly activity. While monitoring is seen as a project activity within the inevitable three to five year time cycle, its potential will never be realised. For monitoring to be successful, programmes must be well designed and ultimately sustainable so they can be continued indefinitely. It is far more costly to maintain a monitoring programme that it is to establish it in the first place.

This paper has attempted to show that the collection of scientific data, through a well designed monitoring programme, can provide information vital to sustainable development in the Eastern Caribbean Islands. Through the revision and application of mechanisms such as coastal development setbacks as described in this paper, it is possible to replace the 'fiction' with 'fact' and to utilize environmental monitoring as a vital tool within the integrated planning process.

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BASELINE DATA SPELLS RELIEF

David Robinson, Nevis Historical and Conservation Society, Nevis.

ABSTRACT

Against a background of an island system approach where the land and sea have one identity, the spatial limitations of small islands and the threats of climate change, the need to evaluate the ability of the environment to accommodate proposed growth must be an important consideration. This paper discusses several beach orientated problems in the island of Nevis and shows how the collection of solid data through a beach monitoring programme has helped to provide some solutions, although not in the area of sand mining. It is suggested that the presentation of factual data is one of the best ways to influence the political directorate and the general public.

BACKGROUND

Nevis, in common with other small Caribbean Islands, is undergoing a period of rapid physical change. The effects of a tourism-driven economy, changing lifestyles of our people and the increasing infrastructural demands of the island community are combining to place unprecedented pressure on the environmental resources of our coastal zones.

Decisions regarding the future of our islands require that decision-makers are provided with the information necessary to arrive at well-formulated plans. No area of planning is more critical than that of environmental protection and utilization. However, the specialized knowledge and manpower required to carry out any meaningful level of environmental and cultural investigation in our islands is for the most part beyond our human resources. One of the primary issues is how to attract this manpower to our islands and then to train and utilize those few human resources we have at home.

We are also in a period when it is critical that government and non government organizations collaborate and that a relatively new planning agency -the Physical Planning Unit - be recognized as taking the primary coordinating role in the protection of our ecosystems.

Solving threatening or existing coastal zone problems means being able to evaluate why the problem exists and to what it can be attributed. Applied to beaches, this means gathering data over a period of time to establish trends, the effects of human interference and abnormal weather patterns in order to establish preventive beach maintenance rather than corrective maintenance. This workshop is about trying to isolate the types of data needed to determine realistic answers for the proper management of our beaches.

SPECIAL SITUATION OF SMALL ISLAND STATES

As small island states there are certain factors that are unique to our situation. Firstly, all oceanic islands by definition are surrounded by the sea and have circular coastal and exclusive economic zones. Most island states have no land frontiers or central terrestrial core distant from the sea. Therefore coastal resource planning is largely synonymous with natural resource planning and management. The island and the sea are truly one identity which make up the island system. There are three coastal zones (marine or offshore, beach and coastal lands) which are ecologically connected because of the fluctuation that takes place within these boundaries. Thus, when man-made developmental activity is added to the ecological complexity of these three zones, the need for effective coastal management becomes increasingly apparent.

Secondly the realities of climate change and rising sea levels are a real threat to water inundation of our low-lying areas, an obvious increase in beach erosion and damage to coral reefs, seagrass beds and mangroves. The consequent removal of natural coastal stabilization factors and vital nurseries for harvestable living resources are further threats.

And thirdly, in regard to the spatial limitations of our small island nations and the interrelated nature of coastal and marine ecosystems in these islands, it is not sufficient for plans to only accommodate growth demands. In the process we must evaluate the ability of the environment to accommodate proposed growth. Inventories must be undertaken to identify and classify coastal lands and resources. Once this data base is established, coastal lands can then be used to establish major development sub-zones based on the limitations of their physical and environmental characteristics. Our economies are heavily dependent on the coastal environments and rely extensively on this zone to sustain economic growth and development, thus national physical development plans must begin to reflect this phenomenon.

SELECTED COASTAL PROBLEMS IN NEVIS

This paper is about the collection of database materials. This workshop is about management issues - our challenge being whether we can determine clear-cut issues and how should we proceed to solve these issues. The following cases raise some questions:

- A major international hotel in Nevis (with room rates beginning at US$ 600 per night without food and which averages close to 65% occupancy year round) is threatened because it must be closed for about a month and a half after its beach disappeared and various buildings are undermined as a result of a hurricane.

- A brand new restaurant is completely destroyed because a hurricane cut away 30 meters (100 feet) of beach.

- The Physical Planning Unit is asked to advise new and existing businesses and home owners about proper setbacks and building types.

- A major wetland is threatened by the encroaching sea and we must estimate how much time we may have before it becomes polluted and destroyed.

- A major hotel wants to keep its existing sand beach and add to it by placing gabion groynes out into the sea.

- Educational programming that accompanies this beach monitoring project is making the local population more aware of the sand problem but is it stopping the illegal taking of sand from the beaches ?

All of these scenarios are Nevis orientated but perhaps could just as well apply to any other Caribbean island.

BEACH MONITORING IN NEVIS

The Nevis experience with beach monitoring has been a most uplifting and fun endeavour. We are now in our eighth consecutive year (the longest consecutive programme within the smaller Caribbean Islands) of quarterly monitoring and sometimes further monitoring after serious storms. This has been a cooperative venture of the Nevis Island Government's Agricultural Department, Division of Fisheries and the Nevis Historical and Conservation Society.

It started when the COSALC programme established beach monitoring in Nevis in 1988. On Nevis seventeen sites were initially identified for data collection. Several more sites were added over the years and several were changed because the basemark disappeared usually because the tree was toppled by a hurricane. The surveys take about five hours to complete and can be done in a day.

We have used many volunteers including school students, Peace Corps and British VSO volunteers, interns and many Society members. The system of measurement is relatively easy to teach, although use of the Abney level instrument can be difficult. But it is not hard to teach someone to do the monitoring. Finding live bodies is something else, however.

Currently we have found that interested retired couples, preferably two sets, work the best. The couples we currently use look forward to packing a lunch four times a year, wearing their bathing suits, bringing their snorkels and trying to swim at all seventeen beaches they monitor. In other words they make a social occasion of the event taking most of the day to do it. Once the data is collected we ask that they come to the office to input the results, which takes less than an hour once the programme is set up to accept the data. What I am now finding is other couples asking if they can do the same which perhaps means adding to the types of data to be collected.

We have altered the data forms to include visual sighting of abnormal conditions such as tar balls, dead turtles, fish, signs of turtle activity, sand removal, pollution and other detrimental effects. These are reported to the Fisheries Division whose responsibility it is to monitor these activities.

The data are then sent the COSALC coordinating centre at the University of Puerto Rico where it is analysed and interpreted to provide answers for use by our Island Government and NGO community.

SOLUTIONS TO COASTAL PROBLEMS - THE APPLICATION OF BASELINE DATA

Lately we have been using the data in a number of beneficial ways. To return to my scenarios:

- The Four Seasons Resort, which employs over 500 Nevisians, lost its beach, part of its pier and had a pavilion and swimming pool undermined during Hurricane Luis. As a result the Resort had to close from mid-September to early November 1995. This meant the loss of considerable amounts of revenue which a hotel of its size and status will not tolerate very long. They inquired about the possibility of dredging sand to stockpile it for present and future use. By using the existing data it was possible to estimate the amount of sand they could comfortably dredge. The operation took place under the auspices of the Physical Planning Unit who kept a record of the work performed. As a result the Four Seasons can now immediately replenish their beach when irregular waves deplete it.

- A restaurant called the Sandpiper had recently opened just before the hurricanes of 1995. The owner was a board member of the Nevis Historical and Conservation Society and an avid environmentalist. He was sure that by building some 30 metres from the high water mark he would have no problems because there never had been a known erosion rate of that magnitude before. At that particular spot the hurricane for some unknown reason eroded the sand to the point where it devastated the restaurant totaling it completely. In this case there were lessons learned and questions asked. Could it have been prevented ?

- The recommended setback for permanent structures is about 90 metres, but most people felt this was unrealistic until now. The hurricane brought a new awareness to developers and owners who turned to the Physical Planning Unit for answers. They responded by establishing tough setback rules for buildings with the actual footage depending on whether it was a permanent of movable structure. They also recommended some beach stabilization procedures. This will eventually lead to a study to determine variable building setbacks at the individual beaches around the island based on eight years of solid data collected for this and other reasons.

- At issue also are the methods of collecting sand. There are those who would avoid dredging as was done at the Four Seasons, because it is robbing from Peter to pay Paul and will only affect other beaches. The building of gabion groynes to help build beaches is common in Nevis and it can be successful. But does it not do the same thing by robbing other beaches of their sand ? Both of these methods for obtaining sand have been carried out in the last year in Nevis and have been documented. We hope to see the results and follow-up from these projects.

- Finally the whole sand issue cannot be ignored. For over ten years the Nevis Historical and Conservation Society has studied, written, lectured, workshopped, brochured etc. etc. until we are blue in the face and we are still wondering if any of it has rubbed off. It is an area that most politicians will not touch, thus most civil servants charged with monitoring the situation will not touch it either. The facts show a direct link between sand mining and our dwindling beaches.

CONCLUSION

In conclusion I would like to return to my original premise about "Baseline data spelling relief". One of the best ways to get the message across to our political leaders and civil servants on the one hand, and our people who should be our advocates, is through the presentation of solid factual data. The beach monitoring data has been used in several ways in Nevis as shown in this paper, but there is certainly much more that can be done. In the first place additional data, besides beach erosion, needs to be collected on our beaches and nearshore resources. Our educational programming can be improved and supplemented and we must keep pounding away on the same themes until we finally get through. Finally meetings and workshops can alert the regional and international community to our critical needs. As small islands in a tough international field, we must make ourselves heard by shouting a bit louder.

NATURAL AND ANTHROPOGENIC CAUSES OF BEACHFRONT EROSION IN ST. KITTS

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ABSTRACT

An investigation into the problem of coastal erosion in St. Kitts revealed that most of the beaches are experiencing erosion. In this paper three beaches were studied : Conaree, South Frigate Bay, and Cockleshell Bay. Measurements for the period 1992 - 1996 showed that all the three beaches had experienced severe beach erosion, especially in 1995. It was found that natural forces were mainly responsible for beach changes. Anthropogenic changes do occur, however, when man aids and encourages these destructive natural forces.

INTRODUCTION

St. Kitts lies in the inner chain of volcanic islands in the northeast Caribbean. It is located at Latitude 17° 15' North and at Longitude 62° 45' West. St. Kitts has an area of 68 sq. miles and is volcanic in nature.

The island of St. Kitts is set on a submerged bank, oriented northwest/ southeast. The coast of the island is backed by lower glacis slopes, which are covered in deep sandy volcanic ash. Much of the coast consists of low cliffs with a variety of particle sizes ranging from silt to boulders. There are some stretches of black sandy beaches found on the southwestern side of the island. Coralline and shelly beach sands, yellow to brown in colour may be found on some beaches, e.g. Conaree and the South East Peninsula beaches.

The beaches of St. Kitts experience an average wave height of between 0.3 and 4.0 m and the tidal range is 0.3 m.

According to Orme (1989) coastal erosion in the Eastern Caribbean has been increasing since 1969. Bearing this situation in mind, the following hypothesis; was suggested: "Natural beachfront changes usually occur in equilibrium and that only via the action of man do these changes become permanently destructive." This paper sets out to explain ways in which nature changes our beaches aided by man's activities.

THE STUDY AREA

Three beach were identified for this study: a) South Frigate Bay, b) Conaree Beach, c) Cockleshell Beach.

South Frigate Bay

This beach is found on the southeastern side of St.Kitts and is washed by the Caribbean Sea. At South Frigate Bay there is a yellow sandy beach, fringed by sand dunes that enclose a salt pond. The beach is exposed to localized wind waves and ocean swells. The coastline of the beach lies in an east to west direction and the angle between the wave fronts and the beach is about 20°. Beach sediment movement is predominantly east to west because of this wave direction.

Conaree Beach

This beach is located on the windward side of the island and is washed by the Atlantic Ocean. The beach consists of yellow sand bordered by huge sand dunes and ridges. Conaree Beach experiences waves primarily from the east-northeast with wave heights from 0.8 to 4.0 m. It is considered to be a high energy beach.

Cockleshell Bay

This beach, on the south coast of St. Kitts, lies adjacent to the channel between St. Kitts and Nevis, and trends east to west. Waves approach the beach from the south-southeast with an average height of about 0.3 m. The longshore current on Cockleshell Bay is weak, moving in a westerly direction. This beach, however, is subjected to considerable southerly storm wave energy associated with the passage of tropical depressions. Cockleshell Bay is characterized by extensive beds of sea grass growing on a sandy substrate. The backshore is characterized by low foredunes rising to larger barrier dunes.

METHODOLOGY

The South East Peninsula Board and the Fisheries Division have monitored beach profiles at the three beaches between 1992 and 1996 using the standard methodology developed by COSALC (Cambers, 1992). Simple surveying techniques using an Abney level, tape measure and ranging poles are employed. A camera was also used to take photographs of the observed beach changes.

RESULTS

Conaree Beach

This beach has only one profile site near the centre of beach. The profile starts at the wall behind the dune at the back of the beach. Table 1 shows the changes in beach width at this site. Between 1992 and 1994 the beach was stable and showed slight accretion. In 1995, this beach experienced extensive erosion due mainly to the passage of two destructive hurricanes in September, Hurricanes Luis and Marilyn. (For the first quarter of 1996 accretion of the beach occurred, while in the second quarter this trend was reversed and erosion of the beach continued to September 1996).

South Frigate Bay

There is only one profile site on this beach. This site is located nearer the eastern part of the beach. Table 1 shows that the beach has been eroding steadily from 1992-95 with the most severe erosion occurring in 1995 as a result of the two hurricanes which occurred in September. The southwestern part of the beach has been completely eroded.

Cockleshell Bay

This is a large beach with profile points at three locations: Cockleshell East, Middle and West. The average change in beach width for the three sites between 1992 and 1995 is shown in Table 1. This beach was fairly stable between 1992 and 1994, with erosion in 1995. For the first quarter of 1996 the erosion rate at this beach slowed, however, erosion continued up to September 1996.

Table 1 Changes in Beach Width at Conaree Beach, South Frigate Bay and Cockleshell Bay between 1992 and 1995

Year	Conaree Beach	South Frigate Bay	Cockeshell Bay
	Beach Width (m)	Beach Width (m)	Beach Width (m)
1992	30.068	25.389	16.730
1993	30.327	24.900	16.270
1994	30.586	23.371	16.190
1995	11.684	5.061	13.020

Table 2 shows a comparison between the mean beach width for the period 1992 and 1995 and the mean beach width for 1996.

Table 2 Comparison between Mean Beach Width 1992-1995 and the Mean Beach Width for 1996

Site	Mean Beach Width (m) 1992-1995	Mean Beach Width (m) 1996	% Variation Relative to 1992-1995 Mean
Conaree Beach	25.66	10.49	-59.12
South Frigate Bay	19.68	4.89	-75.15
Cockleshell East	9.34	10.10	8.14
Cockleshell Middle	18.44	11.63	-36.93
Cockleshell West	18.86	4.48	-76.25

Conaree Beach and South Frigate Bay showed a percentage change of -59% and -75% respectively. Cockleshell Middle and Cockleshell West also showed erosion, with the most severe erosion at Cockleshell West. Cockleshell East is the only site on the beach that showed accretion, this is attributed this to the presence of a groin near this profile site.

DISCUSSION

The results showed that natural changes, primarily resulting from hurricanes, are mainly responsible for the changes at these three beaches in St. Kitts.

From the study of recorded measurements, however, it was found that the natural changes do occur in equilibrium, and that most of the beaches that eroded in one year showed accretion in the following year. The activity of man, however, have been shown to permanently change the coastline without hope of recovery, e.g. the construction of a groin at Cockleshell East and the sea wall at Cockleshell West.

CONCLUSIONS

The three beach sites are showing an erosion trend. This phenomenon has accelerated since the end of the 1980's. The beaches studied experienced natural changes resulting from the passage of hurricanes and their effects.

Of the beaches studied, South Frigate Bay experienced the most severe erosion, this erosion was attributed to natural forces. Conaree Beach suffered erosion that accelerated in mid 1995. This beach also suffers from illegal sand mining. Cockleshell Bay also exhibited erosion that was attributed to natural forces and the construction of a groin and sea wall by man.

Overall the beaches of St. Kitts are eroding mainly because of hurricanes, but man has also played a role in aiding these destructive natural forces.

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HAZARD IMPACTS ON THE CARIBBEAN LITTORAL ENVIRONMENTS: INTERACTIONS OF HUMAN-USE AND NATURAL SYSTEMS

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ABSTRACT

The Caribbean Islands are exposed to three types of natural hazards: hurricanes, volcanic eruptions and earthquakes. These result in billions of dollars of damage. The damages resulting from the recent hurricanes in some of the islands are described. Hazard impacts on coastal environments must be included in sustainable development agendas. There is an urgent need for an integrated approach to land use planning and development control. Improved valuation methods for natural resources are also needed.

INTRODUCTION

> "Disasters are accidental or uncontrollable events, actual or threatened, that are concentrated in time and space, in which a society or relatively self-sufficient sub-division of society, undergoes severe danger, and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfillment of all or some of the essential functions of the society is prevented." (Fritz, 1961).

or

> "An event, natural or man-made, sudden or progressive, which impacts with such severity that the affected community has to respond by taking exceptional measures." (Carter, 1982).

Disaster potential is really a reflection of the interaction of human use and geophysical systems. It is a strong indicator of our efforts to design development programmes that incorporate considerations pertinent to the hazard environment in which we exist.

This paper examines the impact of hurricanes on our coastal environments within the context of our development initiatives.

NATURAL HAZARDS IN THE CARIBBEAN

It has been stated that the Caribbean region is exposed to three of the worst kinds of natural hazards: hurricanes, volcanic eruptions and earthquakes (Tomblin, 1984). Loss of life resulting from the impacts of hazards runs into the thousands, whilst property losses and other damages has reached billions of dollars at present day values. Almost every city in the region has been devastated in the last 300 years.

In the period 1910 - 1930, North Atlantic hurricanes averaged 3.5 per year which increased to an average of 6.0 per year between 1944 and 1980. Since 1960 a slight decrease in frequency has been observed, but intensities and magnitudes have increased significantly. Some of the severest hurricanes of the century have been experienced in this period and include David, Frederick, Gilbert and Andrew. In the 110 years between 1871 and 1980, 119 hurricanes traversed the eastern Caribbean. In that same period there have been years when as many as four hurricanes (1925) and five storms (1916, 1988, 1995) traversed the region (Granger, 1988).

Earthquakes in Jamaica (1692, 1907), in Antigua and Barbuda (1974) and volcanic eruptions in St. Vincent (1812, 1902, 1979) also resulted in loss of life, extensive damage to property and disruption of key productive sectors. In more recent times the disharmony between human use systems and natural systems has resulted in repeated flooding in Jamaica (1979, 1984, 1985, 1988), Barbados (1970, 1984, 1986, 1988) and Trinidad (1988, 1993). Drought as evidenced in St. Vincent in the 1970's and Antigua and Barbuda in the 1980's is another indicator of the need for integration of environmental considerations in our development planning process.

In addition to the "natural" hazards referred to above, the development aspirations of the region have increased the potential for technological emergencies such as oil spills, aircraft crashes and chemical spills.

Whilst we are ever conscious of the hurricane hazard, inadequate attention is given to the seismic and volcanic hazards. The Seismic Unit has advised that there are approximately 25 volcanic centers which are thought to be volcanically active and on whose flanks more than 250,000 people presently live.

COASTAL IMPACT OF HURRICANES

Whilst extensive assessments have been made of the impacts of hurricanes and tropical storms, very little effort has been directed at the coastal elements of these impacts. This is in spite of the extensive economic development activities and national infrastructure exposed to these hazards. According to Nurse (1986), on three south and west coast stretches in Barbados one can find :

- 60% of the total hotel beds,
- $ 250 million of buildings within the zone of the hurricane wave uprush,
- total property value attributable to beaches of $46.4 million.

In Jamaica, the importance of coastal environments in economic activity/ investment and settlement is well described. (Caritech Associates, 1989). Approximately 500 miles of coastline ring the island of Jamaica. The coastal zone supports tourism, fishing, commerce, residential and industrial activities. The main urban centers and key infrastructure installations are located on the low-lying coast. The oil refinery, power generating plants, cement factory, and major public administration buildings all occupy vulnerable coastal locations.

The data from the cursory reviews I have undertaken suggests, that in fact coastal related hurricane damage is usually substantial and often warrants quick access to grants or low-cost development funds, to get the economic engines of the affected entities restarted. The examples which follow provide a cross-section of the coastal interests impacted by storms/hurricanes.

Barbados

The last hurricane to strike the island directly was Hurricane Janet which occurred in September, 1955. The hurricane occurred at low tide and the eye passed off South Point. Maximum winds were 105 knots and came from the west and south.

Sections of the south coast were severely damaged by storm waves. At Hastings, the Hotel Royal and a dwelling house were damaged as the waves crossed the road. On a 3 mile stretch from Worthing towards Hastings, storm waves destroyed seawalls and dumped debris across the road on the backshore.

Hurricane Allen in 1980, passed within 33 nautical miles of Barbados and had maximum winds of 111 knots. The eye passed north of the islands, but storm waves associated with the passage of the southwest quarter of the hurricane inflicted damage to vessels in the Careenage. Beach erosion was recorded at Holetown Bay, Heron Bay, Cobblers Cove Hotel on the west coast, and at Crane Hotel Beach on the south coast.

Jamaica

The center of Hurricane Allen came to within 40 km of the north coast of Jamaica during its passage north of Jamaica on August 5-6, 1980. Major damage along the north and east coast was a result of wave action (storm surge). The luxury hotel, Trident, though raised on a coral platform, was destroyed.

Storm surges were generated up to 40 ft. between Galina and Port Maria on the north coast and Manchioneal on the east coast. Surges in these two localities extended some 200 and 400 yards inland respectively, causing major destruction to houses in Manchioneal. Extensive road damage was also reported along the east coasts and in some areas sand deposition had occurred up to 90 meters inland (Oliver and Trollogee, 1981).

Data on the effects of Hurricane Allen are presented in Table 1.

Table 1 Damage Done by Hurricane Allen, August 5-6th, Manchioneal to Oracabessa

Area	Surge Height (ft)	Houses Flooded	House Tops Blown Off	Houses Totally Destroyed	Houses Damaged	Loss of Crops and Animals	Loss of Fish and/ or Boats
Manch-ioneal	40	48	12	28	12	44	16
Long Bay	20	50	-	-	50	40	-
Port Antonio	28	20	30	2	39	78	7
Buff Bay	18	60	20	10	5	40	-
Armotto Bay	15	8	45	-	54	69	8
Oracab-essa	10	70	20	40	15	25	10
Galina	40	-	-	-	-	-	-

Hurricane Gilbert struck Jamaica on September 12, 1988, causing loss of life and considerable property damage. To complement the efforts of the Government to rapidly establish working groups to assess the impacts, the Caribbean Environment Programme of the United Nations Environment Programme (UNEP) hired a team of regional scientists to focus on the impact of the hurricane on the marine and coastal resources.

Of the fifty beaches reviewed in the survey, 57% were reported to be heavily eroded. Coral reefs in the Discovery Bay area were extensively damaged as reported by the Discovery Bay Marine Laboratory, which had been monitoring the area since Hurricane Allen in 1980.

Bacon (1989) noted the difficulty in applying values to the beach resources. However, he suggested that given the sand, sun and sea component of the tourism product, a value of one third of the tourism earnings may be reasonable. Based on estimated tourism earnings of US $595 million, he suggested a dollar value of US $200 million in losses.

Table 2 presents the losses to a range of coastal and marine resources based on estimations provided by a number of experts. Though only indicative, it suggests the need for refining impact evaluation methodologies and for more focus on resource valuations.

ODPERC (1989) reported that damage to hotels and villas was in the order of US$ 80 million. An additional US$ 5 million was estimated for the rehabilitation of coastal infrastructure.

Table 2 Estimates of Economic Impact of Hurricane Gilbert on Coastal and Marine Resources in Jamaica

Sector	Damage (US $)
Beaches	200
Coral reefs and seagrass beds	100
Lost revenue from visitor arrival (3 months)	33
Repair to coastal facilities	10
Damage to mangrove stocks	10
Fishing industry	5
Total	358

Dominica

On August 29, 1979, Hurricane David attacked Dominica with winds of sustained speeds of 160 mph and with gusts of 200 mph. The main port in Woodbridge was badly damaged and required major reconstruction costing about $ 10.8 million. Damage resulted from the destruction of the main retaining walls and collapse of part of the fill area (Wason, 1984). The old Lighterage Pier at Roseau was also destroyed. Failures of the marine structure were mainly due to high seas which attacked the Woodbridge Bay Port and destroyed the supporting rock protection.

Hurricane Luis passed close to Dominica in September, 1995. Damage to housing was minimal but coastal defences received a severe battering. Approximately 18 breaches, accounting for 8.85 km of coastal defences, were reported, see Table 3. The result was widespread damage to the coastal roads along the west and northeast coasts of the island.

Gabion baskets were the principal structures that failed. Damage was estimated at EC $64.0 million (US $ 23.7 million). An additional EC $ 1.2 million (US$ 0.44 million) in damage to port structure was also reported, (Government of Dominica, 1995).

Table 3 Schedule of Damaged Coastal Defences in Dominica

Location	Nature of Damage	Extent of Impact (km)
Pagua Bay	Damaged gabion coastal protection works	0.6
Mango Hole to Melville Hall	Damaged gabion coastal protection works	0.2
Melville Hall River to Londonderry Bay	Damaged gabion coastal protection works	0.2
Woodford Hill Bay	Coastal protection failed, road	0.1
Calibishie	Damaged sea defenses	0.1
Capuchin Bay	Damaged sea defense	0.1
Toucarie	Damaged sea defenses	0.05
Tantane	Damaged sea defenses	0.3
Cabritts Berth Access Road and Car Park	Damaged sea defenses	0.1
Colihaut School to Anse Cola	Damaged coastal protection structures	0.5
Coulibistrie Village to Batalie River	Damaged coastal protection structures	0.9
Tarou Cliffs to Leper Home	Damaged coastal protection structures	1.0
Massacre Bypass	Damaged coastal protection structures	0.2
Rockaway to Ravine Cocque	Damaged coastal protection structures	1.3
Public Works Garage to Pottersville	Damaged coastal protection structures	0.6
Loubiere Junction to Pte Michel	Damaged coastal protection structures	0.8
Soufriere Village to Scotts Head	Damaged coastal protection structures	1.7
Dubic to Stowe	Damaged coastal protection structures	0.1
Total		8.85

St. Kitts Nevis

Hurricane Luis struck the Federation of St. Kitts Nevis on September 5th, 1995 resulting in extensive damage to the port and surrounding facilities. Beach impact was also quite significant. A rapid reconnaissance indicated that generally, all around the island, the coastline exhibited signs of battering from Hurricanes Luis and Marilyn. The most dramatic signs were noted at Belle Tete, northwest of Sandy Point, formerly an actively accreting beach which was severely eroded. The extent of that erosion encroached inland to the treeline where mature trees with girths in excess of 50 cm (20 inches) were completely uprooted. The volume of sand that was removed was not calculated, but it was suspected that such a figure would have seven digits given the extent of the area affected (0.5 - 3 metres in height and about 5 hectares in surface area).

One immediate implication for the island was that its primary source of 'fine' plastering aggregate had been severely reduced at a time of potentially increased demands. Another was the site's impairment as a recreational area.

The least affected sandy coastal strip on mainland St. Kitts was the Dieppe Bay area where the offshore barrier reef system provided vital protection.

British Virgin Islands

Hurricane Donna was reported to have been accompanied by swells estimated to be at least 20 ft. high, which approached Anegada from the south and swept moored boats over the fringing mangrove. A similar occurrence in 1916 was reported to be just as high. During Hurricane David, the height of the surge was estimated at Prospect Reef Hotel to be about 2.5 to 3 feet above mean sea level. The passage of Hurricane Klaus resulted in damage estimated at about US$ 200,000 to the hotel's breakwater and also caused considerable loss through the destruction of boats which slipped their moorings from the CSY Marina (Lampart, 1986).

THE CONTRIBUTION OF HUMAN USE SYSTEMS TO COASTAL VULNERABILITY

The brief scenarios presented above are not intended to cause any despondency. Rather, the intention is to highlight the substantial social and economic costs which the society is forced to undergo because of indifference, in decision making fora, to environmental considerations and the lack of any clearly formulated environmental management programmes. Several development activities in the region, aimed at meeting the socio-economic aspirations of our people, are placing them at greater risk.

The various accounts of coastal damage resulting from hurricanes have quite clearly been associated with the interaction of natural and human-use systems.

In our small island environment one may say that living is "coastlised". Structures have been created to accommodate tourism facilities and fisheries infrastructure. In many instances, as a result of topographic constraints or historical inertia, infrastructural lifelines are located within the high tide zone of our islands. As these facilities provide a nucleus for productive enterprises and other development initiatives, very high proportions of island resources are vulnerable to storm surges and coastal flooding.

In Barbados, extensive studies of sewerage fall-out from coastal tourism facilities have been linked to extensive modification of marine ecology with consequential modifications of wave action. The unilateral construction of coastal defences such as seawalls, groynes and jetties have resulted in significant modification of wave dynamics in many tourism environments in the region (Cambers, 1985; Caritech, 1986; Nurse, 1989). Destruction of coastal mangroves for charcoal has also resulted in significant modification of the littoral systems in St. Lucia.

Nurse (1986) in examining the impacts of hurricanes on the littoral environment of Barbados outlined the following as contributing to the major coastal erosion problems on the west, south and southeast coasts:

- Improperly located buildings;
- Imperfectly designed structures;
- Improper use of coastal structures;
- Lack of enforcement of present setback requirements;
- Deterioration coastal water quality due to sewage outfalls, increased storm water drainage and refinery outfall, all of which contribute to the deterioration of the reef community;
- Inadequate setback requirements and some disruption of littoral drift;
- Tourism facilities and other structures that extend to and over the high water line;
- The location of the major port and oil refinery in Carlisle Bay which has had a history of storm wave attacks;
- Overdevelopment of land in the coastal strip below 3 m above sea level and resulting in substantial exposure of property to damage;
- Inadequate setback to accommodate erosion rates. Therefore property owners have erected poor structures to protect land when erosion starts;
- Destruction of seagrass and coral communities by pollution and by storm waves. This has

removed protection against storm waves, swell and surges.

In Jamaica, there is also much evidence of man-made coastal change augmenting conditions of vulnerability in the littoral environment (Caritech, 1989). The Montego Freeport Development has incorporated shoals and cays. New beaches and land for waterfront upgrading have been created in the Montego Bay area. Ocho Rios and Falmouth have schemes for development of beaches and expansion of tourist facilities and Oracabessa has had an aborted port development project.

On the south coast, in Kingston Harbour, and the adjacent Portmore - Hellshire, areas have been developed for port and commercial use, and for housing respectively. The Portmore project involved in filling the delta of the Rio Cobre and resulted in the destruction of coastal vegetation communities which absorbed the energy of storm waves.

CONCLUSION

It is evident that given the size of Caribbean Island states and the concentration of economic activity in coastal zones in both island and low-lying states, that hazard impacts on coastal environments must be a matter of central focus in our sustainable development agenda.

Coastal considerations of hazard impact, more than any other focus, brings home the need for an integrated approach to land use planning and development control. It provides an ideal opportunity for refining our approach to integrated watershed management and also provides a demonstration of the need to link disaster loss reduction to the development process.

The general recommendations for reducing coastal vulnerability, see Figure 1, emphasize the need for a review of the mechanisms for inter-agency coordination at the national and regional levels.

We need to expeditiously accommodate a planning framework that embraces consultation and feedback among the stakeholders in sustainable development. Our public sector reform initiatives and institutional capacity building agendas must involve disaster programme managers fully. The planning framework outlined in Figure 2 can represent a point of departure for our discussions on establishing the process necessary to achieve inter-agency consultation and policy feedback.

One must recognize from the outset that what is being proposed will call for significant adjustments and in some instances major reform, of our policy development procedures, public sector decision making and intra-country horizontal cooperation.

Figure 1 Typical Recommendations for Reducing Coastal Vulnerability

TYPICAL RECOMMENDATIONS FOR REDUCING COASTAL VULNERABILITY

1. Support wave monitoring programme to improve the database for storm surge prediction and monitoring coastal processes.

2. Implement measures which will lead to reestablishment of coral communities which are the best storm wave protection.

3. Design crenelated shoreline to improve sediment and current circulation and to discourage reflection of energy on to adjacent shores.

4. Enforce present set-back requirements and revise distance.

5. Prioritize Beach Protection through

   5.1 Prohibiting further destruction of mangrove in vulnerable areas.

   5.2 Revegetating areas which have been destroyed.

   5.3 Creating artificial beaches on eroding shorelines.

   5.4 Prohibiting blasting of reefs.

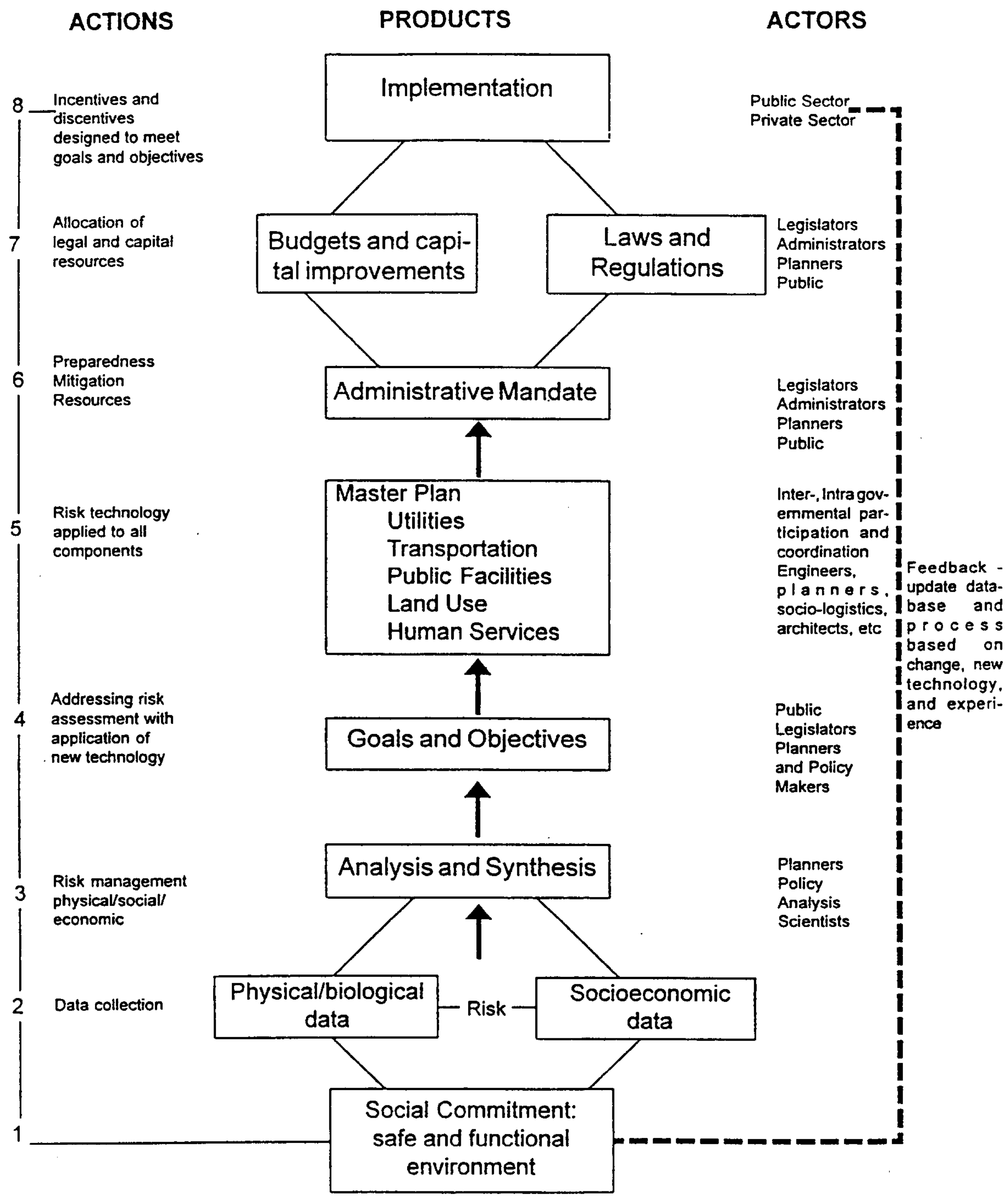
   5.5 Structurally reinforcing natural beach anchors.

   5.6 Control dumping of industrial and domestic effluent on to the coast.

6. Hurricane resistant building codes must be enforced in the coastal zone. These must incorporate horizontal and vertical impacts of storm surge, wave uprush an scour.

7. A coastal zone management policy needs to be developed and incorporated into land use planning.

Figure 2 Mitigation Planning and Implementation Framework



After Lidia L. Selkregg et al., 1984

Given the number and diversity of stakeholders in this agenda the rates of consultation and collaboration must be shared and accepted. Whilst advocacy will be central to the development of a constituency for supporting these surgical initiatives, every effort should be taken to ensure that this is not perceived to be domination by any one shareholder.

The environmental agenda has suffered extensively from territoralism. Too many of our scarce resources are spent on trying to establish individual or agency supremacy, as opposed to mobilizing resources for commitment to the larger goal of a safe and sustainable habitat.

I raise the issue, because sustainable development initiatives must of necessity broaden the shareholders' base. In the Caribbean context this must include disaster management professionals. We (scientists and technocrats) have under-achieved in our attempts to have our environmental policy and strategies accommodated because of two reasons:

1. Preoccupation with professional superiority; and
2. Unwillingness to lead advocacy campaigns.

The issue of professional superiority has contributed to weak inter-disciplinary linkages and initiatives which must be part of the sustainable development effort. In addition, a critical base of information sources has been marginalised because of our attitude towards traditional wisdom. Participatory approaches to problem formulation and policy implementation will be meaningless, unless we explicitly address the current bias in knowledge sources centred around preoccupation with the superiority of certain disciplines.

In the area of impact assessment, it is quite evident that we need to work more assiduously at establishing better benchmark data on our existing resources. Of equal importance is the need to devise resource valuation methods that better allow us to place dollar losses to our natural resources. The initiatives of the University of the West Indies Center of Environment and Development (UWICED) in this regard are promising, but to attain meaningful and acceptable tools, interdisciplinary consultation and consensus will be critical.

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THE IMPACT OF RECENT TROPICAL STORMS AND HURRICANES ON DOMINICA'S BEACHES

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ABSTRACT

The impacts of nine tropical weather systems on Dominica between 1979 and 1995 are documented. All of these storms impacted the island's beaches, although the most severe were Hurricane David in 1979, Hurricane Klaus in 1984, Hurricanes Gabrielle and Hugo in 1989, and Hurricane Luis in 1995. Most beaches experienced severe erosion. Some sandy beaches were replaced by boulders e.g. at Scotts Head, Rock-a-Way Beach, Belle Hall Beach and Toucarie Beach. At only one site, Batali, the beach had widened as a result of the hurricanes. The loss of coastal vegetation in many places has left the shoreline unprotected and more vulnerable to subsequent storm events. Despite the erosion caused by the hurricanes, illegal sand mining continues. It is recommended that the effectiveness of the Beach Control Ordinance be re-examined and that setback limits for developments close to the beach be enforced.

INTRODUCTION

Dominica is the largest of the islands in the Organization of Eastern Caribbean States (OECS), and has an area of 750 km^2 (289.8 sq. miles). The island is rugged and mountainous, generally with very steep terrain and a narrow coastal plain. The island also has a large number of rivers and streams. Most of Dominica's 75,000 inhabitants live near the coast. Merely 29 miles long and 16 miles at its widest, Dominica is located at 61°25' W Longitude and 15°25 N Latitude, and is oriented generally in a north-south direction. The island has a very jagged coastline which is 146 kilometres (91 miles) long.

Dominica is best known in the Caribbean as the Nature Island, for its tropical rain forests, its many waterfalls, scenic beauty and varied wildlife. The island does not promote itself as a beach destination in tourism circles. However, the island does have a number of sandy beaches which help to make up its tourism product.

The beaches of Dominica are made up mostly of volcanic sand, with a few stretches of coral sand on the north-east coast. Thus the colour of the island's sandy beaches varies from black to grey to light cream. There are approximately fifty usually sandy beaches on Dominica, with lengths varying from about 50 metres to 1.5 kilometres. The beaches on the island are generally narrow.

The uses of Dominica's sandy beaches are similar to those of other Caribbean islands. For example, they are used for recreation, sports (e.g. volleyball), tourism and hotel development, pulling up of fishermen's boats and fishing nets, as turtle nesting grounds and habitat for shore birds, and unfortunately a readily available source of sand for plastering.

Dominica's coastline has been subjected to severe impacts by hurricanes and other severe tropical weather systems, and within recent times some of the uses of a few of the island's beaches have been lost due to changes in the profile and material of these particular beaches. A very small number of sandy beaches have actually accreted as a result of recent tropical systems which simultaneously may have had devastating effects on other beaches. This paper will examine the impacts of hurricanes and tropical storms on the beaches of Dominica over the last one and a half decades. Beach profile measurements for Dominica are only available from 1987.

TROPICAL WEATHER SYSTEMS AFFECTING DOMINICA BETWEEN 1979 AND 1995

With co-ordinates of 61°25' W Longitude and 15°25 N Latitude, Dominica is situated in the "hurricane belt" of the West Indies, and over the last two centuries the island has been hit on several occasions by hurricanes and tropical storms.

It has been reported that hurricanes of varying intensity occur on Dominica on average every 15 years. The first record of a hurricane hitting the island was in 1780, but the two most destructive storms, named "David" and "Luis", hit the island in 1979 and 1995 respectively, i.e. approximately two hundred and sixteen years later. Very destructive hurricanes had also hit the island in 1806, when 131 people died (mostly in the capital), and with the passage of the "Great Hurricane" in 1834 which claimed 200 hundred lives (Honychurch, 1984; Caribbean Conservation Association, 1991).

For the seventeen hurricane seasons occurring from 1979 to 1995, Dominica was impacted by no less than nine (9) tropical weather systems, eight of which were of hurricane strength. However, the three hurricanes which had the most impact on the island were Hurricane David at the end of August 1979, Hurricane Hugo in September 1989 and Hurricane Luis in early September 1995.

Following the passage of a major hurricane much attention is usually focussed on the impacts of the storm on the housing, agriculture, social, communications, utilities and tourism sectors. However, there is usually equally heavy impacts on the environment, particularly on the forests, terrestrial and marine wildlife, beaches, reefs and sea grass beds. Such impacts usually do not make the news in the region.

A summary of the impacts of the nine tropical weather systems on Dominica from 1979-1995 is presented in Table 1. It will be noted that the impacts of each storm varied, and this is based on a number of factors, including the strength of the particular storm, the proximity of its passage to Dominica, and the orientation of its strongest quadrant relative to the island at the time of passage.

Table 1 Summary of Impacts of Hurricanes and Tropical Storms on Dominica, 1979- 1995

Year	Name of Storm	Main Sectors Impacted
1979	(a) H. David	Housing; agriculture; hospitality; communications, Social, Utility, Shipping, Environment (forest, **beaches**, reefs, wildlife). 39 lives claimed
	(b) H. Frederick	Housing (minimal); agriculture (localized); Environment: **beaches** (minimal)
1980	(a) H. Allen	Agriculture; **beaches** (minimal)
1984	(a) H. Klaus	**Beaches**; reefs; hospitality; shipping
1989	(a) H. Gabrielle	Windward coast **beaches**; reefs; roads in south-east, south and north-east
	(b) H. Hugo	Agriculture; forests; **beaches**; reefs; shipping; hospitality; housing (minimal)
1995	(a) TS Iris	**Beaches**, forests, agriculture
	(b) H. Luis	Housing; agriculture; hospitality; utility; social; shipping; communications; environment (**beaches**; reefs; forests; wildlife. One life lost
	© H. Marilyn	Agriculture; housing; environment (**beaches**; forests)

Two of these storms (Hurricane Klaus in 1984 and Hurricane Gabrielle in 1989) did not make land fall on Dominica, and in fact, the island did not even experience strong winds from these hurricanes. However, the heavy surges created by these large systems inflicted much damage to the island's beaches and coastal roads in a few areas on the island. With the passage of Hurricanes Gabrielle and Hugo within a few days of each other in 1989, the first named storm caused much damage on the beaches on the Atlantic or windward coast, whereas Hurricane Hugo damaged most of the west coast beaches, and had little or negligible effect on the beaches on the windward coast.

It will be noted from Table 1 that each of the nine storms which impacted Dominica during the past sixteen years also affected the island's beaches. However, the storms which had the most impact were Hurricane David (1979), Hurricane Klaus (1984), Hurricane Gabrielle (1989), Hurricane Hugo (1989) and Hurricane Luis (1995). Unfortunately, no data on beach changes or recorded observations of the impacts of the storms on the island's beaches occur for the period before August 1987 when the Dominica Beach Monitoring programme was started as part of a regional effort to collect data on beach changes in the smaller islands of the region.

IMPACT OF THE STORMS ON DOMINICA'S BEACHES

The impacts of hurricanes on some of Dominica's beaches have been as dramatic as the impacts on some of the other aspects of the island's landscape. Narrowing of beaches, destruction of the coastal vegetation in the tree line, and the conversion of sandy beaches (which are ideal for picnics) into temporary or sometimes permanent narrow stretches of bouldery shoreline are all too common sights after a hurricane has left the island's shores.

Erosion of Beaches

Although beach profile data does not exist for every beach on Dominica, it may be safe to say that most, if not all, of the island's beaches have been affected by every tropical storm or hurricane to impact Dominica. The intensity of the damage on a particular beach will of course vary from storm to storm. Most beaches have experienced severe erosion, while in a few isolated cases, some beaches have actually accreted from the passage of the storm.

The Scotts Head isthmus at the island's southern tip, which, prior to Hurricane David supported a popular sandy beach and a stand of Sea Grape and Manchineel (one of the most effective plants against beach erosion), was left as a relatively narrow rocky stretch as a result of the passage of that storm in 1979. Only a short, narrow sandy area known as Tou Sable at Scotts Head now remains and it is still used by villagers, other Dominicans and visitors.

The dramatic changes on another popular beach on the island can also be attributed to the effects of Hurricane David. The Rock-a-Way Beach, which on a Sunday or Public Holiday, would be supporting several picnics, football and cricket games, friz-bee games, and other forms of beach recreation, was turned into a stony beach with the passage of Hurricane David and has not recovered since. That beach is located on Dominica's west coast within three miles from the capital.

More recently, dramatic changes also occurred on Belle Hall Beach on the north-west coast. This was also one of Dominica's most popular sandy beaches, and it was covered in boulders with the passage of Hurricane Gabrielle in 1989. That beach showed remarkable recovery following that storm and regained its popularity again until Hurricane Hugo when it narrowed considerably. With the combined effects of the passage of Tropical Storm Iris and Hurricanes Luis and Marilyn in 1995, the beach was again changed to a narrow rocky stretch and had not recovered one whole year after these storms.

Further along the island's north-west coast, the Toucarie Beach also experienced severe erosion as a result of Hurricane Hugo in 1989. It had since recovered but was severely impacted again by Tropical Storm Iris and Hurricane Luis in August and September 1995 respectively. One year after the storms, only the southern half of that beach had returned to sand, but the northern half was still covered in boulders and large pieces of corals. The Bout Sable Beach on the island's east coast was also severely impacted with the passage of Hurricane David in 1979 and has never fully recovered.

Coconut Beach and Purple Turtle Beach, on the island's north-west coast also experienced severe erosion, particularly with the passage of Hurricane Hugo in 1989 and Hurricane Luis in 1995. At Coconut Beach, for example, where the beach was washed away (at least temporarily), sections of the access road were also destroyed, leaving a 5ft drop from the edge of the road to the sand. There has been some recovery since the storms.

Accretion on Beaches

While it is known that most beaches erode as a result of storm swells, a different set of changes may occur on other beaches. Because of their orientation, during a storm some beaches may erode at one end, while they may accrete at the other. However, in a few cases some beaches may accrete along most of their width from the passage of the high intensity storm events. One beach which has widened as a result of a hurricane within recent times is the Batali Beach on the island's west coast. That beach widened by about 5 metres with the passage of Hurricane Hugo in 1989. There was also lengthening of the sand bar on the southern side of the mouth of the Layou River. Fishermen use that area for hauling their canoes.

Impact on Coastal Vegetation

With the passage of every major hurricane, the effect on coastal vegetation has been significant. A variety of coastal shrubs e.g. Hoopwood *(Dalbergia sp.)* and herbaceous plants including Seaside potato (*Ipomea pes-caprae*) are often destroyed. Coconut trees, Indian Almond (*Terminalia cattapa*), Seaside Grape (*Coccoloba uvifera*), Seaside Mahoe (*Thespesia populnea*) and Manchineel (*Hippomane mancinela*) trees are often undermined, uprooted and even dragged offshore by the waves in some cases. The effect of these shrubs, herbaceous plants and trees in reducing the rate of coastal erosion (both from wind and swells) cannot be over-emphasized. Thus the net result of their loss will be a gradually retreating and unprotected shoreline which is left more vulnerable to subsequent storm events.

CONCLUSION

Dominica's environment, including its beaches, are periodically affected by hurricanes and tropical storms which affect the island from time to time. Some of the beaches recover to an appreciable level during the first year after the storm, but in a number of cases, these beaches remain covered in boulders.

And while the evidence of the erosion caused by recent hurricanes can still be seen on many of the island's beaches, the removal of sand still continues on beaches which are adjacent to roads. This occurs, despite notices put out by the Ministry of Communications and Works warning against the removal of beach materials. One also sees buildings which were built close to the shoreline and which were partly destroyed by storm swells being rebuilt on the same spots. One sees new buildings under construction near beaches without adequate setback limits.

There is optimism in some quarters that nature and time will repair the damage caused to the beaches during the hurricanes, but such optimism may be unfounded, particularly in light of recent predictions of hurricane activity in the Atlantic Ocean and what has been happening to our beaches. Thus, while Man may not be able to prevent the occurrence of hurricanes, actions can be taken to reduce the overall impacts of these storms on coastal infrastructure.

In light of the impacts of recent hurricanes on Dominica's beaches, it may be an opportune time for Dominica to re-examine the effectiveness of its Beach Control Ordinance and to adequately enforce setback limits for developments close to beaches.

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HURRICANE IMPACTS IN NEVIS

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ABSTRACT

The effects of Hurricane Hugo in 1989 and Hurricane Luis in 1995 on the beaches of Nevis are discussed. While the pattern of erosion was similar in both hurricanes, with the west coast beaches being the most severely impacted, the magnitude of the erosion was greater in 1995. The combined impact of the two hurricanes has caused retreat of the coastline behind the beaches and this is regarded as a permanent change. The damage to coastal infrastructure was also more severe in 1995, almost every structure on the west coast within 100 feet of the high water mark was destroyed. It is recommended that existing setbacks should be revised to take account of local variations so as to maximize the use of land while at the same time providing coastal buffers to protect buildings during storms and hurricanes.

INTRODUCTION

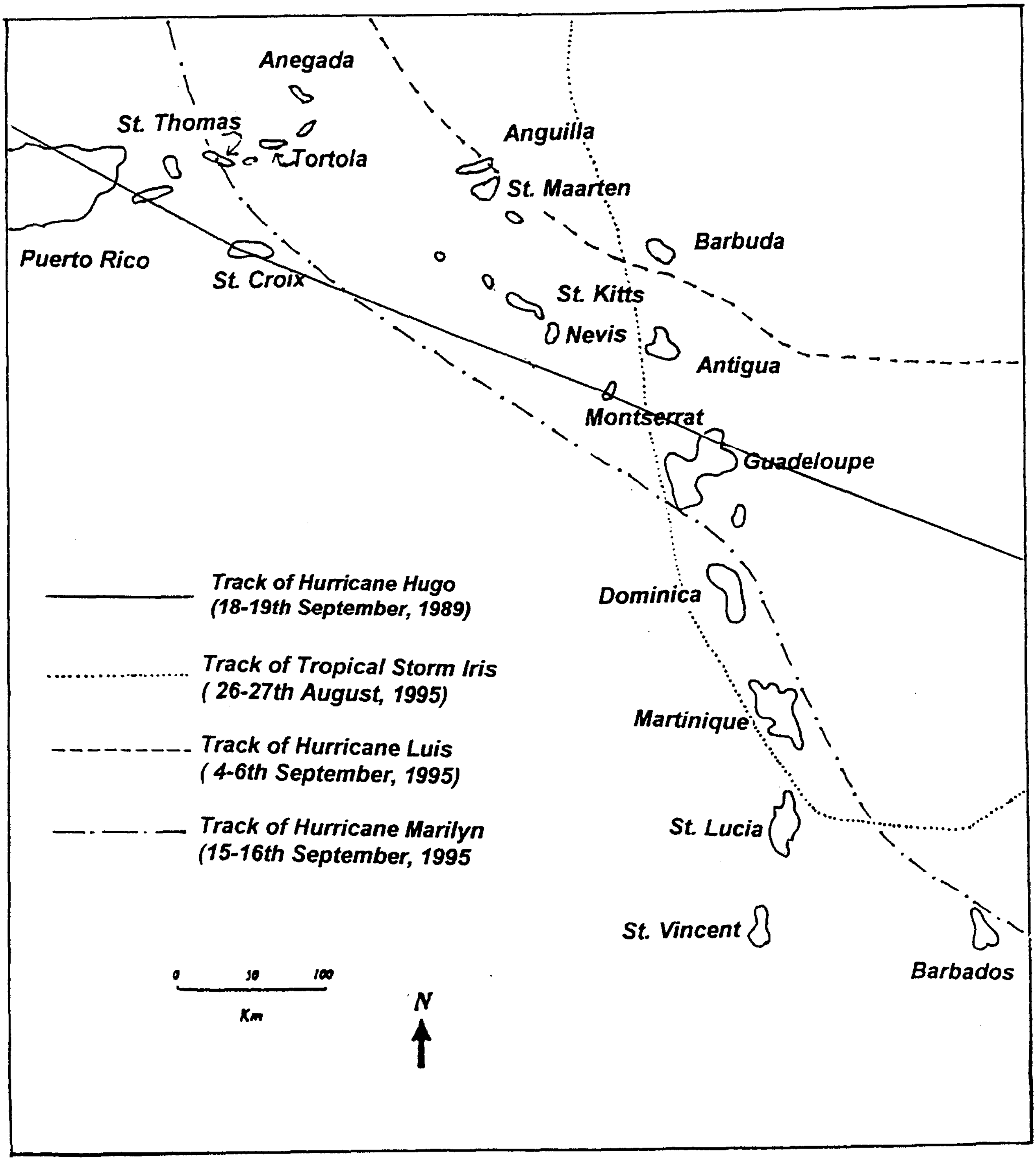
Nevis is an island of 36 square miles with a population of 8,794 persons, that is located at Latitude 17^{0}10' North and Longitude 62^{0}35' West, approximately 3 km (2 miles) southeast of St. Kitts. It is volcanic in origin with a central peak, Nevis Peak, and two smaller peaks in the northwest and southeast. The hills slope gentley towards the coast which is dominated by sandy beaches on the west and by cliffs and rocky shores on the east. The western sandy beaches consist of a mixture of coral sand, foraminifera and volcanic sand, whereas the northeastern beaches are predominantly of coral sand.

Beach erosion has been a major concern in Nevis for many years. Hurricanes are severe natural disasters which have had considerable impact on beaches in Nevis particularly within the last 8 years. This paper will cover the impacts of hurricanes in Nevis within the last 8 years. Figure 1 highlights the passage of the major storms and hurricanes of 1989 and 1995, and the geographical location of Nevis in the Eastern Caribbean Island chain. In 1988, a beach monitoring programme was established with assistance from UNESCO and the Sea Grant College Program of the University of Puerto Rico. Seventeen sites were initially set up, and the data recorded from these sites over the past 8 years forms the basis of this paper.

BEACH MONITORING PROGRAMME

The beach monitoring programme in Nevis is conducted by the Fisheries Division, the Physical Planning Unit and members of the Nevis Historical and Conservation Society.

Figure 1 Tracks of Major Storms and Hurricanes of 1989 and 1995 through the Eastern Caribbean



There are seventeen sites around the island where quarterly surveys are done. Figure 2 shows the beach monitoring sites around Nevis. At each site the beach profile is surveyed from a fixed reference point. The profile area and profile width are calculated.

Figure 3 shows the dominant current patterns and coastal features of Nevis. It is very noticeable that the northern beaches are protected by a band of fringing reef and a large area of sea grass beds, very much unlike the western beaches.

HURRICANES

The hurricane season extends from June 1st to November 30th each year. Several climatic factors influence the formation and activeness of hurricanes and tropical storms along their journey westwards across the Atlantic Ocean. September has been identified as the most active month of the hurricane season for the Eastern Caribbean. Hurricanes and tropical storms can have devastating impacts on lives, the environment and infrastructure. They are categorized according to intensity on the Saffir-Simpson scale as follows:

Tropical Storms	winds 35 - 74 mph
Hurricanes:	
Category 1	winds 74 - 95 mph
Category 2	winds 96 - 110 mph
Category 3	winds 111 - 130 mph
Category 4	winds 131 - 155 mph
Category 5	winds greater than 155 mph.

EFFECTS OF HURRICANE HUGO ON THE BEACHES IN NEVIS

The center of Hurricane Hugo passed 20 km (13 miles) southwest of Nevis on September 19, 1989. In analyzing the impact of Hurricane Hugo on beaches in Nevis, the beach profile data of July 1989 was compared to that of October 1989 (one month after the hurricane). It is quite noticeable from Table 1 that the most severe erosion occurred on the western coast. Pinney's Beach (the prime tourism beach) retreated an average of approximately 17 metres with an average percentage change of 50% in the area under the profile. At least one row of palms at the dune's edge was completely destroyed by wave action. On the northern and eastern beaches however, the erosion was less severe, and in fact a few of the beaches accreted. Nisbett Beach and Newcastle Beach (both protected by fringing reefs) are two noteworthy examples.

On average however, the area under the profile was reduced by 17% and the beach width by 5.2 metres. The results are summarized in Table 2. This reflects a considerable amount of erosion of the beaches in Nevis.

Figure 2 Location of Beach Profile Sites in Nevis

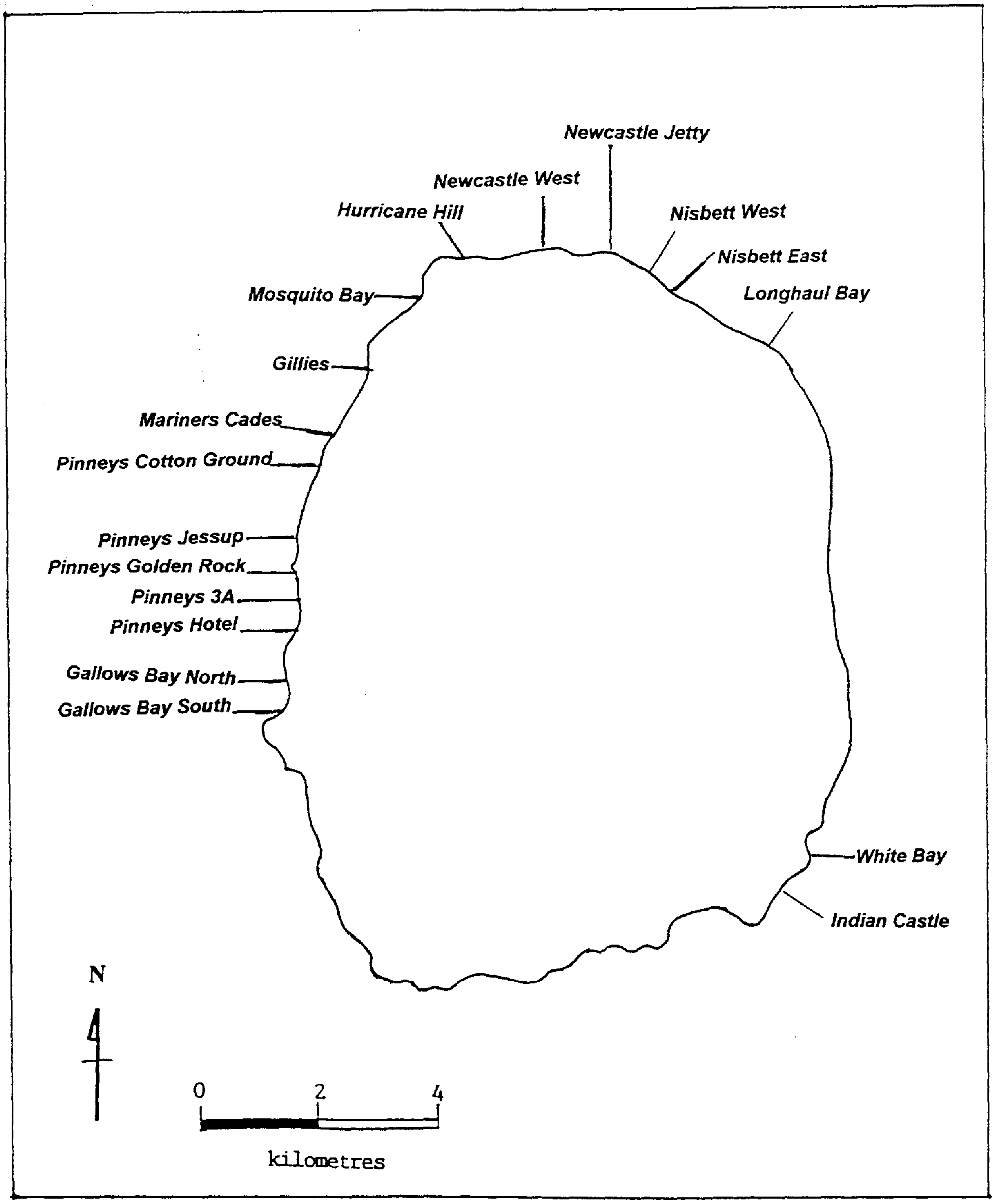
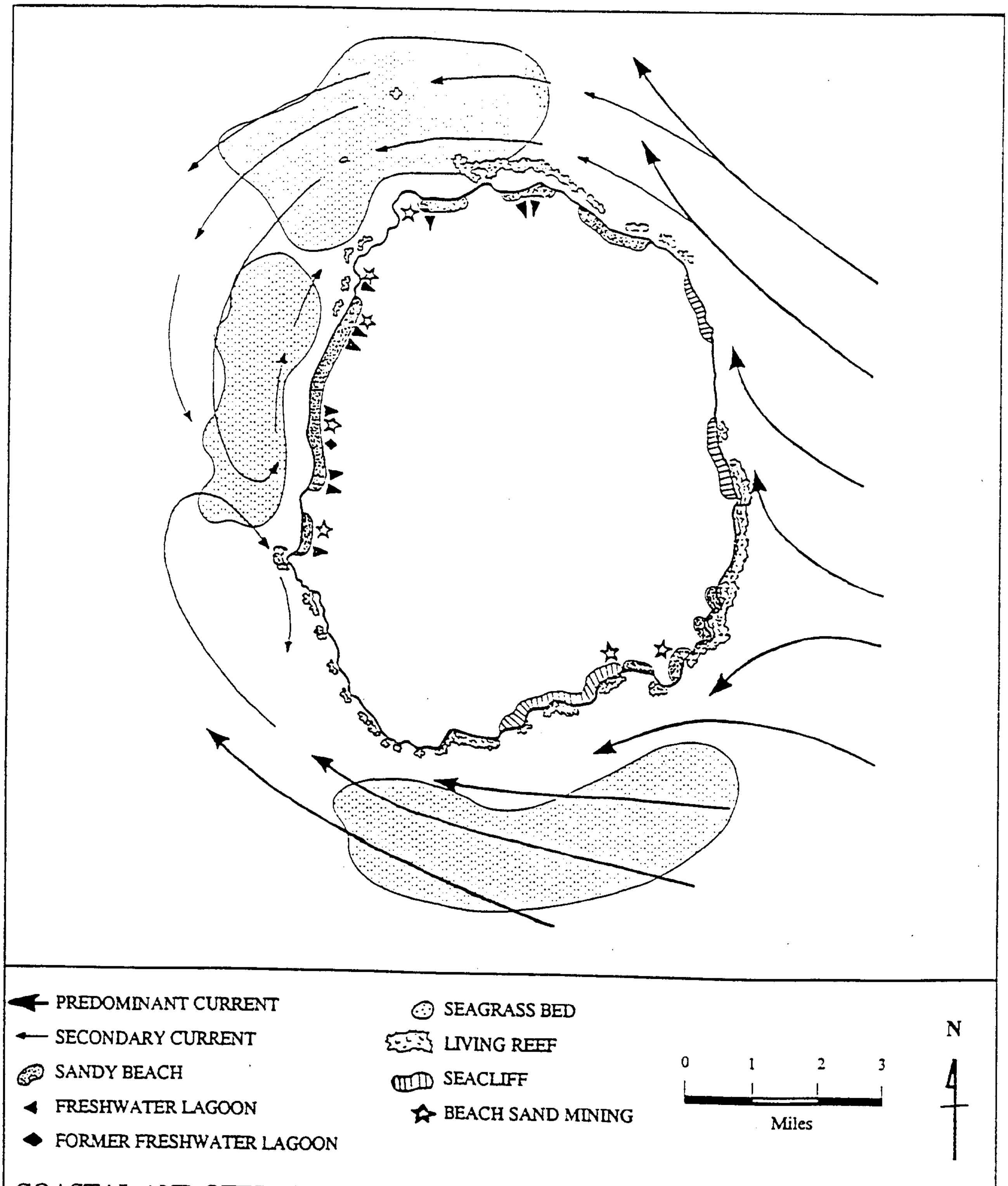


Figure 3 Dominant Current Patterns and Coastal Features of Nevis



COASTAL AND OFFSHORE MARINE FEATURES (adapted from: CCA 1991)

Table 1 Beach Changes in Nevis Following Hurricane Hugo in 1989 (Cambers, 1996)

Site	Change in Profile Area (%)	Change in Profile Width (m)
Gallows Bay South	-11.4	-3.6
Gallows Bay North	-71.1	-16.9
Pinney's Beach Hotel	-66.9	-19.1
Pinney's Golden Rock	-30.5	-17.1
Pinney's Jessups	-57.6	-16.6
Pinney's Cotton Ground	-43.4	-19.6
Mariners	-21.8	-2.3
Gillies	ND	ND
Mosquito Bay	-43.5	+0.05
Hurricane Hill	-5.9	-4.6
Newcastle West	+31.6	+3.6
Newcastle Jetty	+3.8	+5.7
Nisbett West	+45.6	+11.4
Nisbett East	-9.5	-3.2
Longhaul Bay	-3.3	-3.8
White Bay	+12.3	+9.4
Indian Castle	-2.6	-6.2
Mean	**-17.1**	**-5.2**

ND means no data

It is very difficult to calculate beach recovery on any one beach because of the number of factors that will need to be considered. These may include the effect of winter swells and other seasonal changes, the impact caused by sand mining and activities on other beaches, as well as the interrelatedness of beaches. However, for the purpose of this report, beach recovery was analyzed through the most simplistic approach. The pre-hurricane data for July 1989 is compared to the data one year later (July 1990). This is just a short term assessment, for there will obviously be some longer term impacts of the hurricane. Table 3 shows that one year later there had been some considerable recovery of the beaches. The percentage recovery of the profile area was approximately 71% while that for the profile width was 81%. However, it must be noted that the original area and width was never attained. Compared to the July 1989 profile width, the average width of the profile had come within 6.4 metres of the July 1989 width. This is still a significant amount of sand loss. Many of the beaches continued eroding even one year immediately after the hurricane.

Table 2 Summary of Beach Changes in Nevis following Hurricane Hugo in 1989 (Cambers, 1996)

Average change in profile area (%)	-17%
Average change in profile width (m)	-5.2 m
Average change in dune/land edge position (m)	-3.9 m
No. of beaches showing erosion	12
No. of beaches showing accretion	4
The three beaches showing the most severe erosion in order:	1. Pinney's Hotel 2. Cotton Ground 3. Gallows Bay North

Table 3 Beach Recovery in Nevis after Hurricane Hugo (Cambers, 1996)

Recovery of profile area (%) (July 1990 value as a percentage of July 1989)	71%
Recovery of profile width (%) July 1990 value as a percentage of July 1989)	81%
Actual profile width in July 1990 compared to July 1989	-6.4 m

EFFECTS OF THE 1995 HURRICANES ON BEACHES AND NEARSHORE MARINE ECOSYSTEMS

The 1995 hurricane season was the most active and devastating one for Nevis for the century. Three main storms affected the Eastern Caribbean and in particular, Nevis, over the period August 26, 1995 to September 17, 1995. They were:

Tropical Storm Iris (August 26 -27, 1995)
Hurricane Luis (September 4 - 7, 1995)
Hurricane Marilyn (September 15 - 16, 1995).

Figure 1 shows the tracks of these hurricanes. Tropical Storm Iris passed to the west of Nevis and caused little damage to property, but may have accelerated the process of erosion. Hurricane Luis which came only two weeks later and whose center passed 90 km (56 miles) to the east of Nevis caused severe coastal damage. Hurricane Marilyn which came one week after Luis, caused widespread flooding. There was very little left by Hurricane Luis on the coast for Marilyn to destroy, and so coastal damage by Marilyn was minimal.

Table 4 shows the immediate effect of Hurricane Luis on the beaches in Nevis. The data are based on a comparison of the beach profile measurements for June 2, 1995 and September 11, 1995.

Like Hurricane Hugo in 1989, Hurricane Luis (a category 4 hurricane as was Hugo) caused tremendous damage to the west coast beaches of Nevis and lesser damage to the north and east coast beaches. Wilson, 1995, reported that this pattern shows a remarkable concordance with the distributions of sand blanket facies (west coast) and backreef facies (north and south coasts) respectively. Erosion was most severe on the west coast, this may have been due to the predominantly westerly winds causing greater wave energy, while the fringing reefs had a sheltering effect on the east coast. Erosion was most severe at Pinney's Beach and Gallows Bay. Table 5 summarizes the overall average impact of Hurricane Luis on the beaches in Nevis.

The average change in profile area was almost twice that experienced after Hurricane Hugo, thereby suggesting a higher percentage loss of sand. Reference to Tables 2 and 5 shows that more beaches were eroded in 1995 than in 1989. Erosion was so severe in some areas of the beach that "beachrock", a solid, mostly calcareous sand grade rock that develops at depth below sandy beaches below the sediment water/interface, was exposed. This is an indicator of extensive erosion. In the marine debris examined, it was discovered that on the western coast beaches, there was a high percentage of roots of sea grasses as opposed to the eastern coast. On the western coast, the majority of sea grass was of the type *S. filiforme* which suggests that much damage was caused to marine ecosystems some distance out to sea, as *S. filiforme* does not grow for at least several hundred metres from shore.

Table 4 Beach Changes in Nevis after Hurricane Luis

Site	Change in Profile Area (%)	Change in Profile Width (m)
Gallows Bay South	-56.3	-12.8
Gallows Bay North	-594	-5.4
Pinney's Hotel	-76.4	-17.5
Pinney's 3A	-64.6	-4.2
Pinney's Golden Rock	-46.1	-9.2
Pinney's Jessups	-23.9	-5.5
Pinney's Cotton Ground	-48.1	-10.8
Mariners Cades Bay	+5.9	+12.4
Gillies	-63.4	-8.2
Mosquito Bay	-14.0	+0.9
Hurricane Hill	-56.8	-11.2
Newcastle West	ND	ND
Newcastle Jetty	+125.5	+10.8
Nisbett West	-48.1	-8.3
Nisbett East	-66.5	-5.4
Longhaul Bay	+14.1	+3.7
White Bay	-22.4	-16.2
Indian Castle	-14.1	-2.7
Mean	**-29.9**	**-5.7**

ND means no data

Table 5 Overall Effects of Hurricane Luis on Beaches in Nevis in 1995 (Cambers, 1996)

Average change in profile area (%)	-30%
Average change in profile width (m)	-5.7 m
Average change in dune/ land edge position (m)	-5.2 m
No. of beaches showing erosion	14
No. of beaches showing accretion	3
The three beaches showing the most severe erosion in order:	1. Pinney's Beach Hotel 2. Gallows Bay South 3. Hurricane Hill

As for Hurricane Hugo, the beach recovery after the 1995 storms and hurricanes was calculated by comparing the most recent data before the storm to that about one year after the storm. In this case, the June 1995 data is compared to March 1996, as the data for August 1996 was not available, see Table 6. Cambers, 1996, reported that seven months after the hurricanes of 1995, the beaches had recovered on average to approximately 90% of their pre-hurricane levels. Recovery of the area under the profile was about 86% and that of profile width was almost perfect. The net change in profile width was reduction by 1.5 metres. It must be noted however, that factors such as the dredging of approximately 12,000 cubic metres of sand by the Four Seasons Resort to replenish the section of Pinney's Beach immediately adjoining their property may have contributed to this significant recovery.

Table 6 Beach Recovery in Nevis after 1995 Storms and Hurricanes (Cambers, 1996)

Recovery of profile area (%) (March 1996 value as a percentage of June 1995)	86%
Recovery of profile width (%) (March 1996 value as a percentage of June 1995)	96%
Actual profile width in March 1996 compared to June 1995	-1.5 m

EFFECTS OF THE 1995 HURRICANES ON COASTAL INFRASTRUCTURE

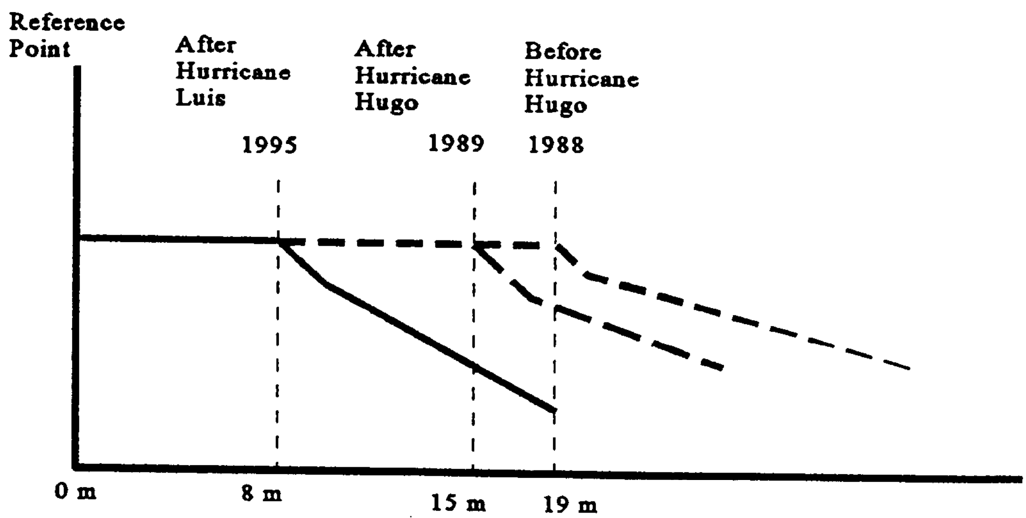
The overall infrastructural damage caused by Hurricane Luis was less severe than Hurricane Hugo of 1989. However, the damage caused to coastal structures was more severe, as these structures were more exposed to wave damage because of narrower beaches. The area of Pinney's Beach (4 km long) was hardest hit. Almost every structure within 100 feet of the high water mark was damaged or destroyed. The scouring effect of the waves was so severe in some areas that along Pinney's Beach, the ruins of a historic fort (once buried) were exposed. Some beaches where structures were completely destroyed included Pinney's Golden Rock, Pinney's Jessups and Pinney's Cotton Ground. The areas north from Fort Ashby around to Nisbett Plantation did not experience severe structural damage from the sea. The primary reason for the damage caused to the beach front facilities on Pinney's Beach is attributed to the close proximity of these structures to the high water mark. In all cases, this is in contravention of the regulations of the Nevis Zoning Ordinance, 1991 which states that:

1. No development shall be nearer than 120 feet from the high water mark.
2. No building shall be nearer than 300 feet from the high water mark.

DISCUSSION AND CONCLUSIONS

Hurricanes are serious natural phenomena which often cause serious disruption of lives. In Nevis, this has implications for the social, economic and environmental well being of the island. It is important therefore for careful planning and development to be done to avert the widespread devastation that can occur. As exemplified in the experiences of Hurricane Hugo in 1989 and Hurricanes Luis and Marilyn of 1995, damage to property and the environment can be unrepairable. In analyzing the effects of the aforementioned hurricanes on Nevis, it is important to point out that none of the beaches have recovered to pre-hurricane levels. Figure 4 shows the retreat of the beach at Pinney's Golden Rock after the two hurricane seasons, 1989 and 1995. This coastline retreat is likely to be a permanent change.

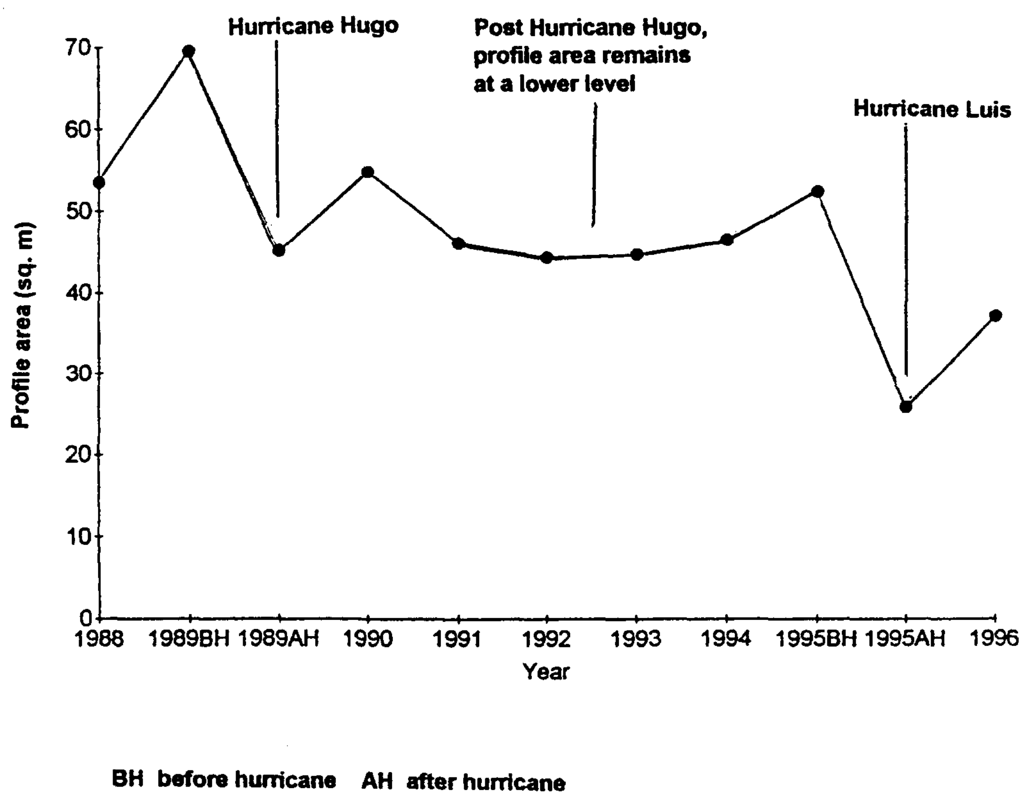
Figure 4 Erosion at Pinneys Golden Rock



Beach profile changes at Pinney's Beach Cotton Ground since 1989 emphasize this statement in showing how the area under the profile has significantly decreased, thereby indicating loss of sand from the system, Figure 5. The patterns of impact for Hurricane Hugo and Hurricane Luis were remarkably similar. The west coast beaches were severely eroded, whilst the north and east coast beaches suffered less erosion and in some cases accretion. It is difficult to attribute this to any one factor, however, it is thought that the presence of an extensive living fringing reef in the north coupled with well established patches of sea grass beds may be a contributing factor. In fact, Hurricane Hugo passed west of Nevis whilst Hurricane Luis passed east of the island, with both having different areas of concentration of force.

It is can be deduced from the data and the beach recovery calculations that the major beach recovery takes place in the months immediately after the hurricane. Overall profile areas remain at a lower level after the hurricane.

Figure 5 Beach Profile Changes at Pinney's Cotton Ground, 1989 - 1996 (Cambers, 1996)



In totality, the serious effects of hurricanes on property can be mitigated for. Planners and other agencies will have to revise the existing beach setbacks and make them beach specific so as to maximize the use of land, and at the same time provide realistic setbacks for buildings against wave damage. However, it will be very difficult and costly to mitigate against damage to beaches. The experiences of the hurricanes described herein suggest that there will be permanent loss of land during a hurricane. Therefore, one will have to provide coastal buffers to alleviate land conflict issues that may arise.

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COASTAL EROSION

Hugh Thomas, Grenada National Museum, Grenada.

ABSTRACT

The origin and type of sediment, whether terrigenous or pelagic, organic or inorganic, provide important indicators regarding sediment transportation routes and the resultant beach erosion and accretion. The geological characteristics of a coastline can provide an understanding of the history and processes that have taken place. This information, together with knowledge of more recent processes taking place today, are necessary for effective beach management programmes.

INTRODUCTION

From a geological standpoint beach accretion or erosion is normal. Knowing where and why it is happening is more important. For an effective beach management programme to be established, knowledge of the source, transportation as well as depositional areas of the sediment must be available.

SEDIMENT TYPES

The sediments on the beaches originate from either terrigenous (land) or pelagic (sea) environments. Each of these sources is then divided into either organic or inorganic, this is determined by a percentage greater than 30% of its composition being organic or inorganic.

The terrigenous inorganic sediments are generally coarser - silicates, quartz and feldspar minerals. The pelagic organic sources are coral, calcareous, and siliceous. Inorganic sources come from volcanic and glacial materials. In the majority of cases the land is the major source of the sediments on the beaches.

Agricultural development, cultivation of lands, has two basic effects:

(1) Soil erosion, the soil particles end up in the streams and rivers and are consequently transported to the sea. Fresh and salt water have different densities and therefore different abilities to carry sediment. The ever increasing sediment may accumulate, hence, redirecting tidal flows.

(2) Due to the increase in the use and abundance of different fertilizers, increased nitrates and sulphates reach the coastline. The organic life cycle is greatly damaged, leaving the

reefs a mere shadow of their former selves.

The effects of the demise of the coral and shell life can be seen in two ways. Firstly, if the reef was the major source of sediments on the beaches, then as the years go by, there will be a decrease in the amount of sediments reaching the beaches. In reality these reefs take hundreds of years to grow to the level where a significant supply of sediment can be obtained, but destruction can take only a few years. Secondly, in some cases where the reef acts like a barrier to the force of the incoming waves, the full force of these waves will reach the beach if the reef is no longer intact.

Observations about the origin of sediments can be made from factors such as colour, texture and chemical composition. It is very important to explain at this point that 'sand' as we know it is not a type, but a size of particle. Rocks are eroded and weathered removing the softer elements from their structures leaving only the hardest minerals in the arrangement. Granulites and schists break down into grains of quartz, feldspar and mica. Although to the naked eye, sand on the beaches may all look alike, its origin could be quite different. From the knowledge of the types of sediments, the source or sources of these particles can be located as well as the transportation method and route. Thus it is important to look at the origin as well as the final resting place of the particles.

Different types of landforms present interesting contrasts. A simple example is the case where the coastline has alternating layers of rocks. This means that for years the softer layers have been exposed, so that the processes involved in the breaking down of the sediments happen at a faster rate. After 50 or 100 years this soft layer is finally worn away leaving the harder layer. The rate of erosion of this harder layer is much slower than that of the softer layer. Therefore, the supply of sediments is severely reduced. To the casual observer, not much has changed in the coastline in the last few years, and the sudden decrease of the width of the beach may be inexplicable.

TIDAL CURRENTS

It is important to know the strength and direction of the major and minor tidal currents. The strength of these currents determines the size and quantity of sediments which can be transported. Once these currents are slowed, as for instance through meeting another current flow or meeting some sort of barrier, man made or otherwise, some of the energy in the currents will be lost which means that the currents cannot carry as much sediment as before. As a result, deposition takes place.

Why would tidal patterns change? This can be caused by the destruction of natural barriers or construction of artificial ones e.g. jetties. The destruction of natural barriers, such as reefs, cannot always be seen. The incoming waves and tidal currents now have more energy. Instead of these waves and currents depositing silt, they are now eroding. The sediment may be moved offshore or alongshore to another part of the coastline. Artificial barriers cause wave diffraction, wave energy may be distributed over a narrower area and the waves become more powerful, thus causing greater erosion.

HURRICANES AND TROPICAL STORMS

The action of very powerful forces such as tropical and extra-tropical storms and hurricanes have lasting effects on the beaches. The beaches may never recover during a person's life span. The damage that could be done from a few hours of a storm or hurricane could destroy decades of accretion.

The angle and width of the berm play some part in how it will be eroded. To a lesser extent the composition of sediments and their grain size on the beach also helps determine the erosion. As a result of the strong winds and pressure gradients of severe storms, surges occur such that water levels rise several feet. The volume of water reaching the shore increases. Strong waves therefore reach the loosely packed sand at the back of the beach. This sand, which may have taken as long as 100 years to build up, is now lost forever. Different storms and their winds may come from a variety of directions. Thus the effects of one storm on a particular beach may be very different to the next storm.

BEACHES: FORM AND PROCESS

In the first place, the origins of the beaches must be examined. Coastal forms may result from one or several processes, these include land erosion, river deposition, wind deposition, volcanic forces, wave erosion and marine deposition. Different coastal forms have a different rates of erosion given the same conditions.

A wind deposited beach, for example, will have sediments of very similar size usually fine enough to be transported through the air. The cementation of such a coastline would be different from that of a volcanic coastline. An increase in the number of storms will leave permanent damage to the coastline. The rate of erosion also depends on the degree of exposure to the higher energy wave action. Broader beaches have a smaller tidal range because of the wider distribution of energy.

As long as there is no change in the elevation of the landmass relative to the ocean surface, cliffs will continue to retreat, until the beaches widen sufficiently to prevent waves from reaching the base of the cliffs. The eroded material will be carried from the high energy areas and deposited in low energy areas.

One of the currents along the coast is called the longshore drift. The longshore current moves the sediment that is stirred up by wave action along a beach or coastline. This increases with increasing beach slope. To a lesser degree, the raising of land levels and/or sea levels has an effect on the slope of the coast, hence changing the erosional and depositional environment. This process is somewhat slower than the others mentioned before.

CONCLUDING REMARKS

While all these processes are taking place, some quicker than others, sand mining is the most damaging process of all for a beach. Whereas in all the previous cases examined the sediments eroded from one area are deposited in another, in the case of sand mining there is no balancing of the equation. The sand is constantly removed to the permanent detriment of the coast. If sand mining takes place at such a fast rate as to remove this first barrier for the waves, the beach, then in times of storms, massive erosion occurs of the land behind the beach.

It is important to realize that erosion and accretion are natural phenomena. Thus erosion in some areas is inevitable.

LAND BASED POLLUTION, REEF HEALTH AND NEARSHORE SEDIMENT PRODUCTION ON OCEANIC ISLANDS: A BARBADOS CASE STUDY

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ABSTRACT

Between the 1970's and the 1990's, deterioration in the ambient nearshore water quality resulted in changes in the benthic ecology of west coast fringing reefs of Barbados. Reduction in the abundance of reef forming organisms, namely corals and coralline algae, as well as mass mortality of the grazing urchin (Daidema antillarum), and increases in macroalgal cover has resulted in dramatic changes to the sediment budget. Calculations suggest that on the north Bellairs fringing reef, calcification has declined to 17% of its 1970's level, whilst bioerosion has remained at a constant level. This has resulted in bioerosion now exceeding calcification, a reversal of the 1970's situation. Data from other west coast fringing reefs suggests that this is indicative of the condition along that coast. A sustained imbalance between reef bioerosion and construction will lead to a decline in sediment generation, the potential loss of reef structure and increased hydrodynamic activity at the shoreline. Medium to long-term changes in associated beach cells are expected, with accelerated modification if impacted by severe storm events.

(This paper will shortly be published in a peer reviewed journal)

B. THE MANAGEMENT OF BEACH SAND MINING

ENVIRONMENTAL EFFECTS OF SAND EXTRACTION PRACTICES IN PUERTO RICO

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ABSTRACT

Over the past four decades, sand has been extracted from the beaches, sand dunes, alluvial floodplains and residual sandy soils in Puerto Rico. This has resulted in accelerated beach erosion, among other impacts. The paper discusses various solutions to the problem of sand supply for the construction industry. Besides extraction from already utilized sources, other solutions are described: importation, manufactured sand, offshore deposits and substitute building materials. The paper recommends developing the offshore deposits and the use of manufactured sand.

INTRODUCTION

During the past four decades, the extraordinary development of Puerto Rico has altered the dynamic equilibrium between the supply and demand of sand in Puerto Rico. Progress is usually measured in terms of the concrete poured into structures. The availability of concrete as a construction material directly depends on the feasibility of extracting the sand resources. The increase in the consumption of sand depleted the accessible sources in the beaches and coastal dunes, and the price of the commodity rose abruptly. The extraction operations caused acute soil and beach erosion problems and the island lost expensive real estate properties to the sea. Thus, Puerto Rico began to lose its beaches, a natural resource of greater recreational and touristic potential than the use of sand as concrete aggregate. The Puerto Rican experience can serve as a guide to the smaller Caribbean Islands in the management of their beach resources.

As the Government limited the extraction from the beaches, the operations were transferred to river channels, alluvial floodplains, and residual sandy soils. These extractions caused problems related to soil erosion and sedimentation of the bodies of water. When the residual sandy soils were strip-mined, bedrock was exposed on the ground surface and agricultural terrain was lost. Also, coastal sandy areas were dredged leaving pools of stagnant waters. The coastal dunes were depleted eliminating the natural coastal protection along the shoreline from Loiza to Aguadilla.

CAUSES OF BEACH EROSION

Beach erosion is generated by either natural or artificial causes. Beach erosion is caused locally by natural phenomena or man-made works. The natural causes are: (1) the world-wide rise in sea level, (2) recent diastrophic movement, and (3) destruction of the protective barrier reef.

Global warming causes the glacier ice to melt around the North and South Poles. The melting of the ice caps causes a world-wide rise in sea level. A rise of sea level in Puerto Rico or the Caribbean region, where the tide range is only one foot, could easily trigger a cycle of beach erosion.

Puerto Rico's and other Caribbean Islands' coastal geomorphic features show evidence of recent diastrophic movements. The island of Puerto Rico has suffered a major tilting in the past. The northeastern and southwestern coasts are coastlines of emergence, while the southeastern and northwestern coasts are coastlines of submergence. The island is also located close to the northern earthquake belt of the Caribbean Tectonic Plate. During the 1918 earthquake, the sea receded on the west coast. These changes in elevation of the land have generated beach erosion cycles.

Poor coastal management practices, marine pollution, dredging operations, and other human activities have degraded the water quality in the vicinity of the reefs. An imbalance between growth rate of the reef-forming corals and erosion generated by wave action has rapidly destroyed some coral reefs. A considerable retreat of the shoreline is attributed to the destruction of the protective barrier reefs by the devastating attack of swells, hurricane waves and tsunamis.

Beach erosion is caused artificially by man's action. During the past four decades, man was responsible for most of the beach erosion. The eroding human activities are outlined as: (1) reducing the supply of sand by damming most of the major rivers or building river improvement structures, (2) changing the configuration of the coastline by coastal development such as ports, groins, jetties, revetments, land reclamation projects, and sea bottom dredging operations, and (3) removing sand from the beach zone and coastal dunes for commercial purposes. The removal of sand from the beach zone has created the worst and most difficult erosion problem.

SOURCES OF SAND

The sources of sand are classified as marine and terrestrial deposits. The two most common marine sources are the deposits on the shore and offshore. The most common terrestrial sources are the river channel deposits, floodplain alluvial deposits, and residual soil deposits.

There are extensive deposits of sand on the shores of the island, occurring in the intertidal zone, where sand grains are deposited by the littoral drift. The beaches vary from narrow strips parallel to the coastline to broad inland deposits of more than a kilometer in width. Although these deposits were extensively mined in the past, the extraction of sand from the maritime zone for commercial purposes was prohibited by an Administrative Order of the Secretary of Natural and Environmental Resources in 1993.

Some large sand deposits occur in the back beach zone. These are usually found as sand dunes and series of consecutive ancient beaches. Most of these deposits have been extracted in the past. The back beach deposits were usually in private land, where government had no jurisdiction until Law No. 138 was approved in 1968. Although it is possible to extract a portion of the dune without eliminating the coastal protection, the determination of the extraction area and buffer zone is difficult without detailed geologic studies.

The offshore deposits are classified into: (1) the submerged deposits of the island shelf, and (2) the deep sea deposits. The material available in the deep sea deposits is usually too fine-grained to meet the specifications and so deep that it is usually not economically feasible to dredge. Several deposits submerged under the island coastal shelf have been already explored by government and private enterprises. No permits have been granted to dredge these deposits. The explored deposits the are following:

Locality	Estimated reserves in million cubic yards
Escollo de Arena, Vieques	46.0
Las Cabezas Bay , Fajardo1.	1.4
Ensenada Comezon, Rio Grande	0.9
Ensenada Boca Vieja, Toa Baja	2.5
Punta Verraco, Guayanilla	6.0
Punta Cuchara, Ponce	6.4
Boqueron Bay, Cabo Rojo	5.7
Guanajibo Bay, Mayaguez	5.5
Anasco Bay, Anasco	0.1
Espiritu Santo Submerged River Channel	0.1
Loiza Submerged River Channel	0.2
Isabela Submerged Coastal Island Shelf	20-25.0
Cabo Rojo Submerged Island Shelf	8-13.0
Condado Lagoon	1.4
San Jose and Los Corozos Lagoons	0.5
Torrecillas and Pinones Lagoons	1-4.5
Guayanilla Bay	1-5.0
Radas Roosevelt	3-8.0
Cayo Largo Inshore	0.5
Boca de Cangrejos Submerged Island Shelf	0.6-1.0
Guanica Bay	0.5-1.0
San Juan Bay	24.0
La Plata Submarine River Channel	0.3-0.8
Total	135.6-150.5

SOLUTIONS TO THE PROBLEM

The immediate problem in Puerto Rico - a relative scarcity of sand - could be resolved by increasing the rate of extraction in the existing permits, but this action will reduce the life of the deposits. The long-range solutions studied are the following:

Exploiting Renewable Beaches

If the quantity of sand deposited in the beach is greater than the amount extracted, theoretically sand extraction should not cause beach erosion. However, the quantity to be extracted without causing erosion is insignificant to supply the construction industry. Comprehensive studies must be conducted on the supply of beach sand, littoral drift and accountability of the amount extracted.

Extraction from Coastal Dunes

The beach sand blown by the wind accumulates behind the beach deposits forming dunes which protect the coastal lowlands during storm surges. Most of the sand dunes have been excavated and eliminated in Puerto Rico due to poor management practices in the past. Thus, this will not be a feasible option to supply the construction industry at the present time.

Dredging River Channels

Since the principal rivers of Puerto Rico have been dammed, the sediment load does not reach the sea because it accumulates in the reservoir and the river sediments are not restored as in the past. The lower segments of the river channels are undernourished and the channels will not restore themselves; however, the higher reaches of the river have enough material to serve as a source of sand. These operations require washing and sorting which causes water pollution. Therefore, the wastewaters must be disposed into a sedimentation pond before discharging the clear overflow into the river. The upper reaches of the reservoir are areas where sand and gravel are deposited when the river flow is checked and loses its coarse sediment load.

Dredging the River Floodplains

Floodplains adjacent to river channels are usually dredged in Puerto Rico. Although large amounts of sand and gravel are obtained, ponds are often created losing the agricultural potential of the land. These excavations must be backfilled to regain the land use values. The material needs washing and sorting; thus, sedimentation ponds are needed before discharging overflow to the nearby bodies of water.

Extraction of Inland Residual Sandy Soils

Some rocks weather to sandy residual soils which can be excavated, washed and sorted to produce sand. These operations can initiate a cycle of soil erosion if not properly managed. Once the material is removed, the area should be planted with grass or any other suitable vegetation. Sedimentation ponds are also needed before the overflow is discharged to the environment.

Dredging Submerged Deposits

The submerged deposits can be dredged, but of all those deposits studied, only three could be dredged without damage to the environment: (1) Cabo Rojo Islands Shelf, (2) Isabela Island Shelf, and (3) Escollo Arena in Vieques. All the others will cause considerable environmental damage.

Substitution of Concrete

The concrete can be substituted by other materials such as steel, bricks, wood, plastics, dimension stone, light aggregate, and other materials. This presently is being done in Puerto Rico.

Importation of Sand

Oolitic sand has been imported from the Bahamas, but the physical properties of these materials do not always comply with the specifications for concrete. This sand is usually too fine, completely spheroidal, poorly sorted, and wears easily. On some occasions, it has been suggested to import sand from the Dominican Republic and other countries of Central America, but shipment must pass through the U.S. Department of Agriculture. Therefore, this option is feasible, but requires a period of quarantine. Anyway, Puerto Rico would be exporting its environmental problems to another country.

Manufacture of Sand

Crushing rock, recycled glass or recycled plastic to sand-size particles, can produce a sand which complies with specifications for concrete mixes. There is sufficient rock in Puerto Rico to make this operation economically feasible; however, the price of the commodity will be higher than extracting it from the beach, river bed or residual soil.

RECOMMENDATIONS

The construction industry could be facing a crisis by the end of this century, if an adequate supply of sand is not secured within this decade. In order to solve the problem the following measures are recommended:

A. Protection of Beaches, Dunes and Shorelines

- Legislation - A law should be enacted prohibiting the extraction of sand for commercial purposes from the beach zone.

- Enforcement - Wardens to patrol the beach zone should be entrusted with greater authority to reduce the clandestine extraction operations.

B. Research Needs

- Inventory of sand resources - A systematic study of the deposits of sand around the island of Puerto Rico should be conducted. The study should estimate the available reserves and the economic feasibility of mining operations.

- Development of submerged deposits - A promotional program for the development of the submerged deposits should be undertaken. Incentives, lines of credits, loans and technical aid should be offered by the government. Deposits could be exploited in conjunction with the development of other by-products. The establishment of coastal distribution points from stockpiles should be developed to maintain the independent truck owner with a steady supply of raw material.

- Beach erosion study - A comprehensive study of all the beaches of the island should be undertaken to determine the present conditions of each beach, their optimum potential, protective measures required and the order of priorities. This study should include the artificial nourishment of beaches by dredging offshore and depositing the sand on the under-nourished beaches. Financial aid can be obtained from the Federal Government to restore certain beaches.

- Manufacture of sand - A promotion program for the manufacture of sand must be undertaken. Incentives, lines of credit, loans and technical assistance should be offered by government. The existing quarries could easily manufacture sand and the production of sand from recycled materials could prove economically feasible.

SAND MINING IN GRENADA
ISSUES, CHALLENGES AND DECISIONS RELATING TO COASTAL MANAGEMENT

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ABSTRACT

Sand mining in Grenada has been identified as one of the main contributing factors to beach degradation. Beach sand accounts for 100% of fine aggregate used for construction purposes. In recent years rapid growth in tourism, building of private homes and businesses, and the laying down of new agricultural roads have generated a marked increase in the demand for beach sand. This increased demand for beach sand on the one hand and the heightened appreciation of the value of beaches as habitats, protective barriers and places of recreation among others have served to concentrate the attention of both resource managers and the general public on the urgent problems associated with beach degradation. This paper explores issues related to conflicts in uses, jurisdiction, legislation and education. While alternatives to beach sand exist, it is unlikely that they will be implemented soon. As an immediate strategy it is therefore recommended that the existing legislation be rigidly enforced.

INTRODUCTION

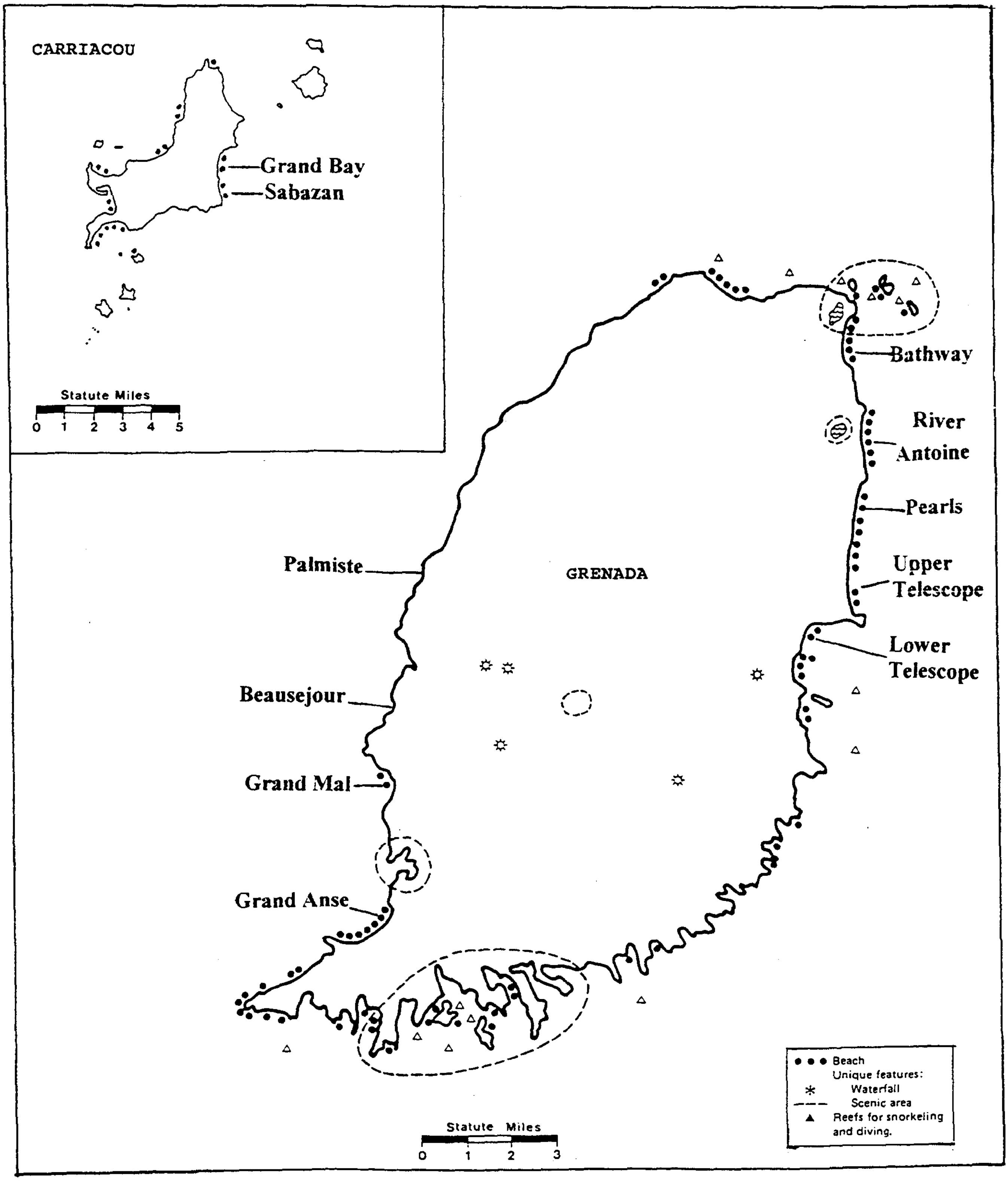
The tri-island state of Grenada, Carriacou and Petite Martinique (population 93,830 in 1993) is located close to the southern end of the Caribbean archipelago. The state lies between Trinidad and Tobago in the south and St. Vincent and the Grenadines in the north. This state shall hereinafter be referred to simply as Grenada.

There are numerous sandy beaches in Grenada of various sizes, see Figure 1. Many of them, e.g. Grand Anse, Levera, La Sagesse, Paradise are very popular among Grenadians and visitors alike. The existence of these beaches has meant a ready supply of fine aggregate for use in the production of concrete for building and road construction. In addition beach sand is one of the main components of the filtering process used by the National Water and Sewage Authority (NAWASA) in the production of potable water.

In the absence of more accessible, or cheaper, natural sources of fine aggregate for the purposes outlined above, the mining of beach sand in Grenada has provided, and will continue to provide 100% of the requisite fine aggregate.

It is estimated that between 52,000 and 65,000 yd^3/yr of beach sand are mined in Grenada (Gabriel, 1995). The negative impacts of sand mining on beach aesthetics and use, not to mention coastal stability have been recognized by many agencies and even by "the man on the street".

Figure 1 Sandy Beaches in Grenada and Carriacou.
(Source: ECNAMP, 1981)



These concerns are probably what prompted the enactment of the Beach Protection Act of 1979 which empowers the appropriate minister to impose controls on sand mining activities.

However, with the past expansion of the construction industry in recent years and the projected future increase (Francis *et al,* 1993), together with the failure of the relevant authorities to introduce an alternative to beach sand, sand removal will certainly increase the stresses on the mined beaches, and sooner or later those that are not presently mined.

It is clear that measures that have so far been instituted to manage and control sand mining activities have not been effective. There is sufficient evidence to suggest that the illegal removal of beach sand is more extensive than the authorities admit.

If observed changes in the public's attitude towards beach conservation persist, then there will more pressure for greater attention to be paid to protecting Grenada's coastline. However, the current administrative "grey areas" and legislative loopholes need to be sorted out in the interest of maintaining equity among beach users. Sand mining is increasingly coming into conflict with other beach use activities - a situation that is expected to exacerbate over time.

THE MINING OF SAND

Very few sandy beaches in Grenada are totally immune from sand mining no matter how small the scale. Table 1 shows the different levels of sand mining.

Table 1 Criteria Associated with Each Level of Sand Mining

Level	Equipment/Persons Involved	Estimated Quantity Removed per Trip (approx.)
Small scale	Shovel, buckets, bags, push cart/wheelbarrow, small pick-up truck 1 - 2 persons	50 - 1,400 lbs
Medium scale	Shovel, small trucks (< 5 tons) Usually 3 persons	2 - 5 yds
Large scale	Shovels, front end loaders, large trucks (> 5 tons) 4 - 6 persons	5 - 16 yds

Table 2 shows some examples of affected beaches (Cambers, 1995). Each of the beaches have been subjected to large and medium scale sand mining in the past.

Table 2 Selected Beaches Affected by Sand Mining (Cambers, 1995)

Site	Period	% Change	Change in Width m/yr	Trend	Comments
Upper Telescope:					
West	1987-1990	-22	-1.1	Erosion	Sand mining
Central	1985-1990	-15	-0.7	Erosion	Sand mining
Beausejour:					
North	1985-1988	-24	-0.5	Erosion	Sand mining
Central	1985-1990	-10	+0.15	Erosion from 1988	Sand mining from 1988
Grand Mal	1985-1990	+12	+0.04		
Palmiste:					
South	1985-1990	-8.0	-0.4	Erosion	Sand mining
North	1987-1990	-30	-1.7	Erosion	Sand mining

The negative effects of sand mining have been well established and acknowledged even by those who are engaged in the practice both legally and illegally. Francis *et al* in a 1993 committee report on the question of sand importation states "The continued mining of sand on Telescope, Grand Mal and other beaches, coupled with high erosion rates on Grenada's premiere tourist and recreational beach, Grand Anse, is of dire concern to the Government and people of Grenada."

His sentiment was somewhat echoed by Gabriel (1995) when he observed that "notwithstanding natural causes, mining of beach sand seriously aggravates the situation." Many others have written and spoken in a similar vein. The paradox here is that this acceptance and understanding has not been translated into affirmative action by way of mitigation. Clearly the question of how the issue of sand mining has been handled by the relevant authorities requires further examination.

JURISDICTION AND CONTROL

There is no single agency in Grenada responsible for environmental issues (Caribbean Conservation Association, 1991).

The Beach Protection Act of 1979, Section 2 makes the removal of "sand, stone, shingle or gravel from the seashore " illegal. However, Section 6 of the same act empowers the "Minister to exempt any person(s) from the conditions of Section 2".

The Ministry of Communication and Works (which incidentally is the largest miner of sand) interprets the Beach Protection Act (1979) to give jurisdiction over beaches to the Minister and Permanent Secretary of that Ministry. The act itself does not specify any particular minister. This author, with assistance from the Legal Department of Grenada, has so far not been able to unearth any official document that thus specifically empowers the Minister of Communication and Works.

The office of the Attorney General submits that the expected appropriate Minister would be the one holding the portfolio of "The Environment". The Department of the Environment is located within the Ministry of Health and the Environment. This department is rarely consulted on environmental matters except as far as they relate human health. Indeed the department's interpretation of "Environment" is restricted to "Environmental Health", i.e. waste disposal. But the confusion does not end there because it is generally felt that the Fisheries Division (within the Ministry of Agriculture) is responsible for "Coastal Management" which would include beaches. Whereas the Fisheries Act (1986) and the Fisheries Regulations (1987) does provide limited power over beaches when considered as habitats, it has no power over sand mining.

A number of other agencies (including NGOs) have genuine concern and involvement in coastal management but none with decision making nor enforcement power.

The extent of the Ministry of Works' management of sand mining has been limited to the reduction of the number of beaches that can be mined legally from six to two, (Gabriel 1995). These beaches are Pearls beach in St. Andrew's on the mainland and Sabazan Beach in Carriacou, see Figure 1. This Ministry is also of the view that is has been effective in the prevention of illegal sand mining - a belief that contradicts the observation of other workers in the field.

Given the plethora of overlap and the amorphous distinctions between departments with regard to jurisdiction, it is not surprising that uncontrolled sand mining has proceeded unhindered. There is a clear need for cohesion here.

POLICY AND PUBLIC ATTITUDE

In Grenada the issues related to sand mining have received attention at the policy making, i.e. cabinet level. Alternatives to sand mining have been considered and a few studies undertaken. However, no definite policy has emerged as a consequence of these deliberations and/or studies. According to Ministry of Works officials, there are no plans to seek alternative aggregate to beach sand anytime soon.

Meanwhile there appears to be growing unease and dissatisfaction among the public regarding sand mining. Sand mining has received "negative press" at every public forum attended by this writer where coastal zone management (CZM) was discussed. In addition very often callers to radio call-in programmes have deplored the practice of illegal sand mining and have urged government intervention to curb the practice. There is no doubt that more people are taking beaches seriously - especially with the almost daily reinforcement by advertisements put out by the Grenada Board of Tourism.

In some instances public disapproval of illegal sand mining has been translated into action - some owners of beachfront property have resorted to digging deep trenches across roads in order to deny vehicular access to the beach. People from communities close to legally mined beaches often resent the fact that "their" beach is being mined thus robbing them of a "quality place" for rest and recreation.

THE FUTURE OF SAND MINING IN GRENADA

The demand for fine aggregate for the production of concrete has not abated - in fact the demand is expected to increase. In the absence of any well formulated policy on the supply of fine aggregate, legal sand mining will continue. Illegal sand mining will also continue as a result of ineffective enforcement of the Beach Protection Act (1979). Illegal sand mining will probably increase if any alternative introduced is viewed as being comparatively too expensive.

In 1993 a "Seven Man Committee of Professionals" was formed by the Ministry of Communication and Works to analyze the "OECS/Guyana Sand and Supply Feasibility Study" (Atkins, 1993). The committee was mandated to make recommendations to the Ministry of Communication and Works.

In its report the committee gave a "thumbs down" to the proposal to import sand from Guyana. The committee was concerned about the inherent risks of inadvertently importing agricultural pathogens and other pests which could have disastrous effects on the islands vital agriculture sector - the so-called backbone of the nation's economy. Furthermore, the committee cited the loss of foreign exchange, together with the increased cost of the sand itself as well as its inland transportation, as additional arguments mitigating against the importation of sand.

The report also considered two other alternatives namely off-shore dredging and the use of crushed gravel. It was felt the first option "....could have severe impact on our environment, especially coral reefs..." and by extension the nation's fisheries. Experiments were then being conducted by the Gravel Rock Asphalt and Concrete products (GRACP) on the suitability of crushed gravel as an alternative aggregate. The committee found that preliminary work by GRACP suggested that concrete construction can be carried out "without the use of sand as we do now."

In its recommendations the committee proposed inter alia that more work should be done by GRACP on the crushed gravel and that the ministry involve building contractors in the testing of the resulting aggregate. The convening of a national consultation on sand mining was also recommended.

There are no indications that any recommendations made by the above mentioned committee, or any other similar body, has ever been implemented or even given serious consideration. It is a reasonable assumption that sand mining will continue for some time yet. Once this is accepted then in the interest of preventing further degradation the following ought to be strictly applied:

(i) Rigid enforcement of the Beach Protection Act (1979) to prevent illegal sand mining.

(ii) Where sand mining is legal there should be strict controls and a proper monitoring programme initiated and maintained.

(iii) Consideration should be given to the formation of a broad-based (government, NGOs, individual) committee receiving full parliamentary support with sufficient power to make certain decisions and/or recommendations on matters related to coastal zone management.

ACKNOWLEDGEMENTS

I wish to extend my appreciation to the undermentioned persons for their kind assistance in the preparation of this document: The Hon. Mark Isaac, Minister of Health and The Environment; Mr. Winston Gabriel, Chief Technical Officer, Ministry of Communication and Works; Mr. Peter Thomas and Ms. Gail Hypolite, National Science and Technology Council; Mr. Finlay, Gravel Rock Asphalt and Concrete Products; Mr. Paul E. Phillip, Mr. Junior McDonald and Mrs Fernette Sylvestor of the Fisheries Division, Ministry of Agriculture and Fisheries.

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EFFECTS AND IMPLICATIONS OF SAND MINING IN TOBAGO

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ABSTRACT

Beach sand mining is a serious problem affecting coastal areas of Tobago. During the last fifteen to twenty years, there has been an increase in the construction industry, as a result of population growth and rapid development in the tourism sector. Unfortunately, Tobago lacks naturally occurring deposits of sand and gravel, which has resulted in a shortage of building aggregates. Historically, beach sand was the accepted source of aggregate. This practice is no longer acceptable, but has been difficult to stop. Within the last five years sand has been removed from beaches in increasing amounts to alleviate aggregate shortage. Several beaches such as Great Courland, Richmond, Goldsborough, Little Rockly and La Guira have been mined for sand and as a consequence have all undergone severe erosion. Even though beach sand mining has stopped at some of these beaches, few have been able to recover. Several alternatives to beach sand mining are being considered, with the importation of aggregate from Trinidad being the most viable option.

INTRODUCTION

Beach sand mining has been a traditional way of obtaining aggregate for construction in Tobago. This is because Tobago, unlike Trinidad, does not have natural deposits of sand and gravel. During the last fifteen to twenty (20) years, there has been a marked increase in construction activity related to population growth and rapid development in the tourism sector.

Part of the mandate of the Institute of Marine Affairs (IMA) is to conserve the marine resources for the benefit of Trinidad and Tobago and as such since the early eighties, the IMA has been assessing the impacts of sand mining on the beaches of Tobago. During these studies, the IMA indicated to the Tobago House of Assembly (THA) that the indiscriminate and uncontrolled extraction of sand from the beaches was impacting severely on the marine environment.

Besides coastal erosion, sand mining activities have caused such environmental problems for Tobago as:-

1. the creation of large sand pits along the beach;
2. a loss of coastal vegetation;
3. the penetration of the sea further inland;
4. loss of property; and

5. the loss of bathing beaches.

In 1984, the THA in conjunction with the IMA, designed a sand and gravel resource project the objectives of which were to compile a sand and gravel inventory, establish site selection criteria and extraction techniques, determine which beaches are appropriate for mining, and monitor mining sites.

The IMA in 1989, established a coastal conservation project to monitor the coastal erosion problems in both Trinidad and Tobago. These monitoring studies have recorded the dynamic nature of the beaches which exhibit a seasonal movement of sand. During the period November to April which coincides with the winter storm weather in the North Atlantic, sand is moved offshore and onshore during the summer months (May to October) when calmer conditions exist. The studies also revealed that the rivers in Tobago contribute very little sediment to the development of the beaches and as a consequence when sand is removed from a beach, the sediment budget suffers from an imbalance of sand and as a result erosion occurs.

This paper uses the data from these two projects to highlight the effects and implications of beach mining activities on some beaches in Tobago.

DESCRIPTION OF THE STUDY AREA

The island of Tobago with an area of 300 km^2 is located at the southeastern corner of the Caribbean Plate. The island can be described as having a humid tropical climate with a mean temperature of 26°C. Tobago is situated within the belt of the North East Trade winds and experiences two seasons annually, a dry season from January to May and a wet season between June and December.

The northeastern two-thirds of the island is mountainous and is made up of metamorphic and volcanic rocks. The coastline in this region is generally rocky and rugged (Bertrand *et al.*, 1991) with indented bays. The south western region of the island is flatter and is covered mainly by coral-algal limestone of late Pleistocene age. The coastline in this region is less rugged and the bays are open and exposed.

HISTORY OF BEACH SAND MINING AND ITS EFFECTS AND IMPLICATIONS

Since 1980 the IMA has been monitoring and assessing the impacts of beach sand mining in Tobago. The first such study was undertaken at Turtle Beach, Great Courland Bay, see Figure 1, by Georges (1984). At the western section of this beach, the Black Rock River drains into the bay. The mouth of this river was the site of mining operations during the early eighties.

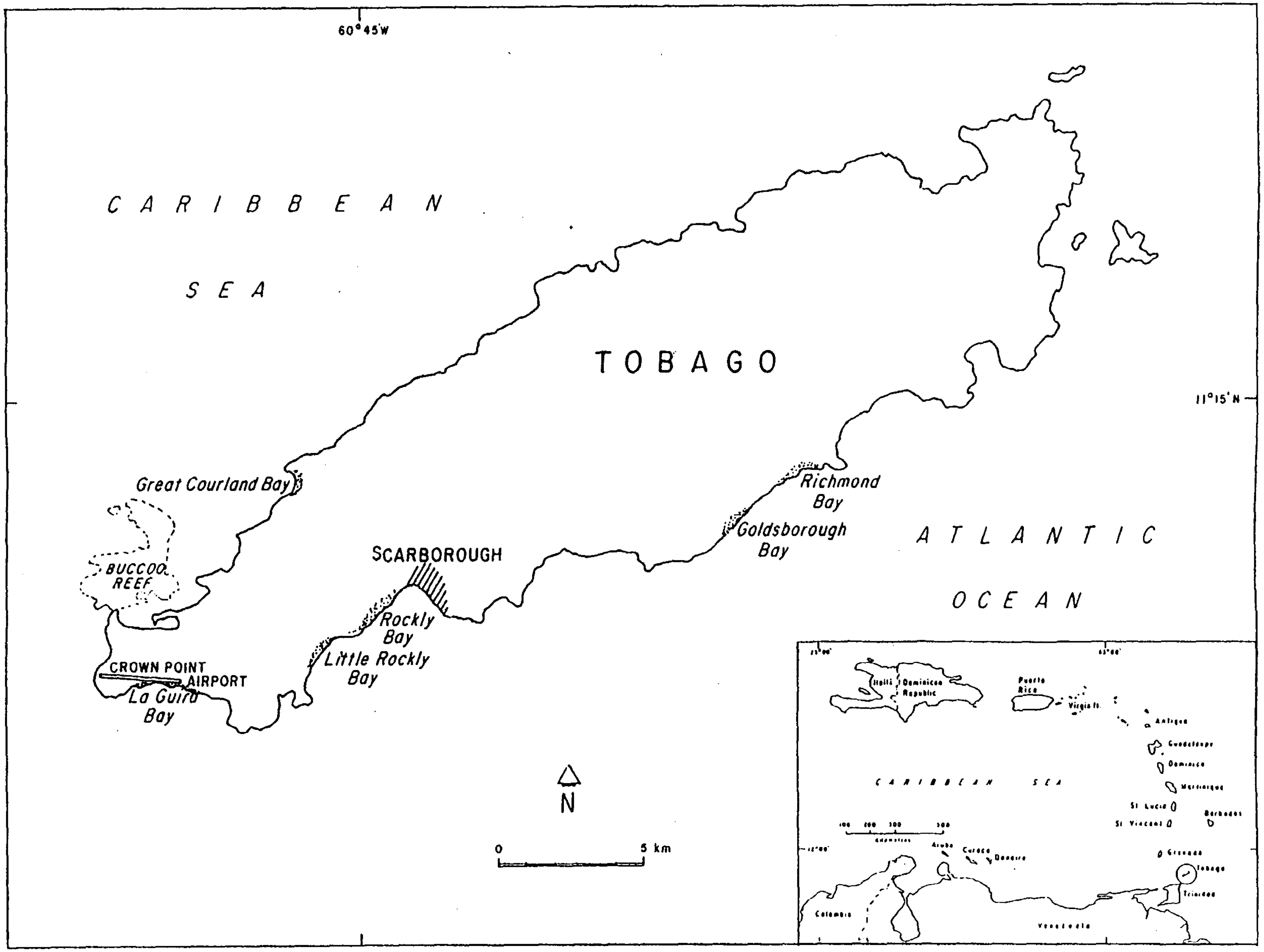


Figure 1 Map Showing Some Beaches in Tobago Which Have Been Mined

This study (Georges,1984), indicated that Turtle Beach undergoes cyclical patterns of sediment accretion and erosion due to the seasonal variations in wave energy conditions that exist within this bay. The results of the study also indicated that there was a progressive reduction in berm height near the mining site which was attributed to the fact that sediment was being removed from the system faster than it was being replaced by natural processes, thus creating a disequilibrium. The mining activities within Turtle Beach resulted in the erosion of the western section of this beach. Recent monitoring studies conducted by the IMA (September, 1996) have indicated that the beach has not recovered from the sand mining activities and it is still undergoing erosion at a significant rate. This has resulted in the construction of coastal defence structures (rip rap revetment) by owners of property located along some areas of the western section of Turtle Beach.

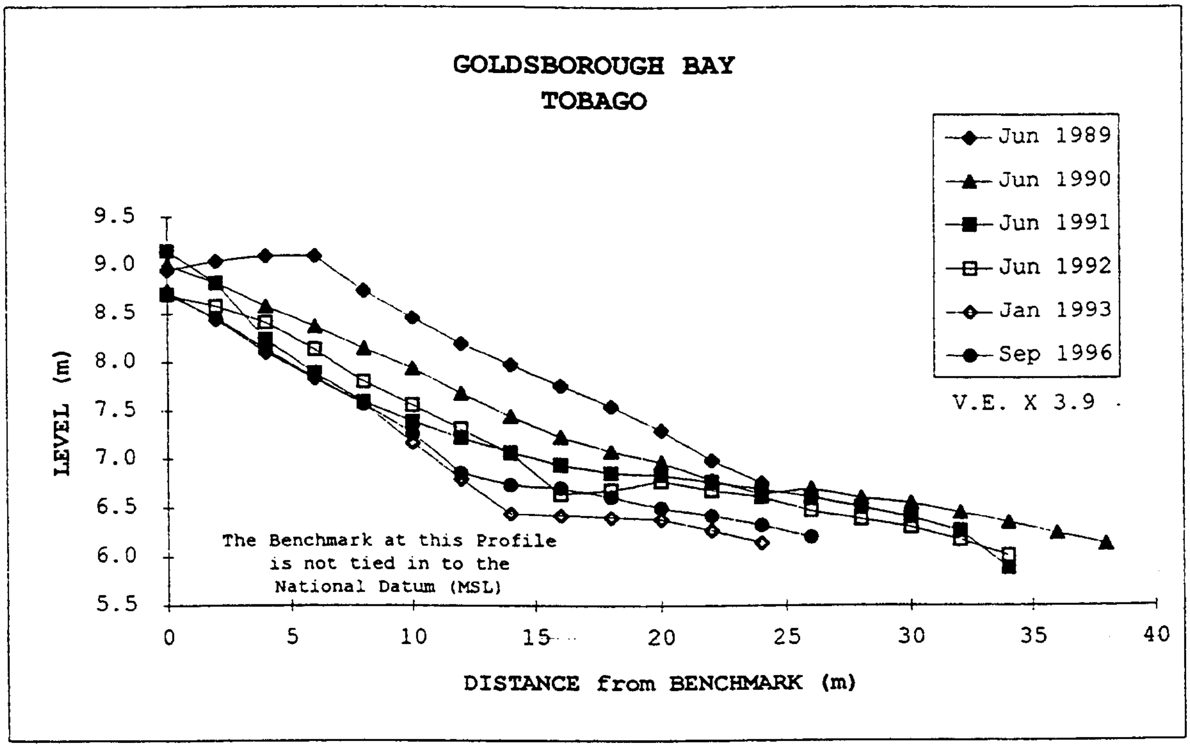
After the closure of Turtle Beach to beach sand mining activities, the THA began to give licenses to remove sand from Goldsborough Beach, see Figure 1, in 1983. This beach also began to undergo serious erosion, which Bachew and Lewis (1985) attributed to the fact that there was no control in the quantity of sand which could be removed from the beach and there were not any restrictions as to the periods of the year when removal could take place. There were also no regulations to the mining techniques that should be employed. Bachew and Lewis (1985) indicated that if appropriate controls had been implemented, the adverse environmental impact would have been reduced. The impacts of beach sand mining at this beach were significant, as the beach was mined until the top soil layer became exposed. During mining at Goldsborough Beach, some of the lush vegetation was removed from the backshore areas, while some was destroyed as a result of saline intrusion. Beach sand mining also caused a change in the physiography of the beach, from gently sloping to steep, Figure 2a, with a distinct vertical scarp at the western section of the beach. This change in beach morphology resulted in the waves breaking closer to shore and as such the beach became more vulnerable to wave attack.

In 1986, Goldsborough Beach was closed to mining activities due to a reduction in the supply and the THA moved mining operations to Richmond Beach, which is located along the south coast of Tobago, Figure 1. Studies were conducted within this bay as part of the IMA's sand and gravel project and a preliminary assessment was prepared by Bachew (1986) which recommended that this beach could be mined in the short term with certain controls and restrictions (such as location, duration and quantity), so as to minimise the environmental impacts.

These recommendations proposed by the IMA, were not adhered to which resulted in significant erosion taking place at this beach. Some of the impacts were: loss of mangrove vegetation which fringed the coast, intrusion of saline water into the backshore and loss of a recreational beach for the residents of the area. Figure 2b shows that the eastern section of Richmond Beach continued to erode up until September 1996.

A study on the nearshore processes and sedimentation at Queen's and Richmond Bays was undertaken by O'Brien and Lawson (1986) and it was recommended that Richmond Beach should not be mined as the beach was approaching dynamic equilibrium and any removal of sand

Figures 2a and 2b: Beach Profiles Showing the Changes in Beach Morphology since Sand Mining Started.



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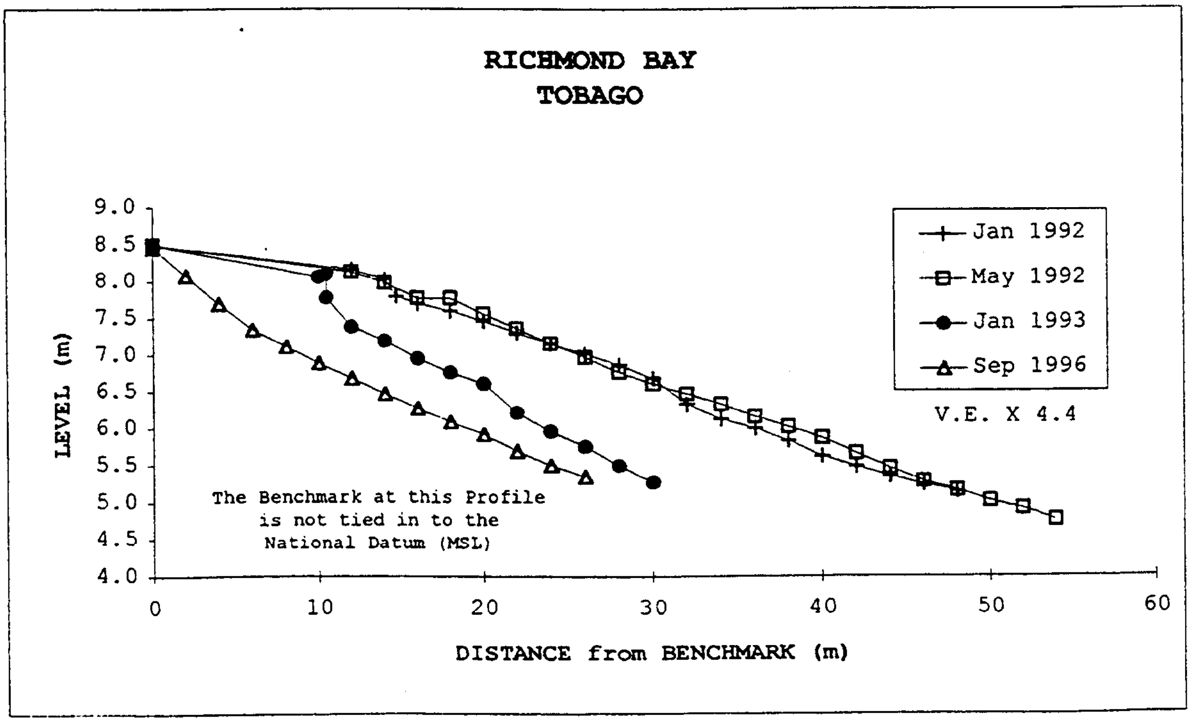

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from the beach would upset the sediment budget and erosion would occur. Prior to the closure of Richmond Beach to sand mining, as the supply became exhausted, the THA commissioned the IMA to identify another beach for the extraction of sand pending the establishment of a crushing plant in Tobago. Based on a study undertaken by the IMA at Goldsborough Beach in 1988, results indicated that the beach was in a process of rehabilitation and that sand mining activities could be reinitiated to satisfy the short term demand. The IMA (1988) gave recommendations for mining in order to avoid any further disastrous erosion effects on the beach as occurred previously. The IMA also recommended that mining should be completed by the end of May 1988. However, this recommendation was not adhered to, and Goldsborough Beach underwent significant erosion again.

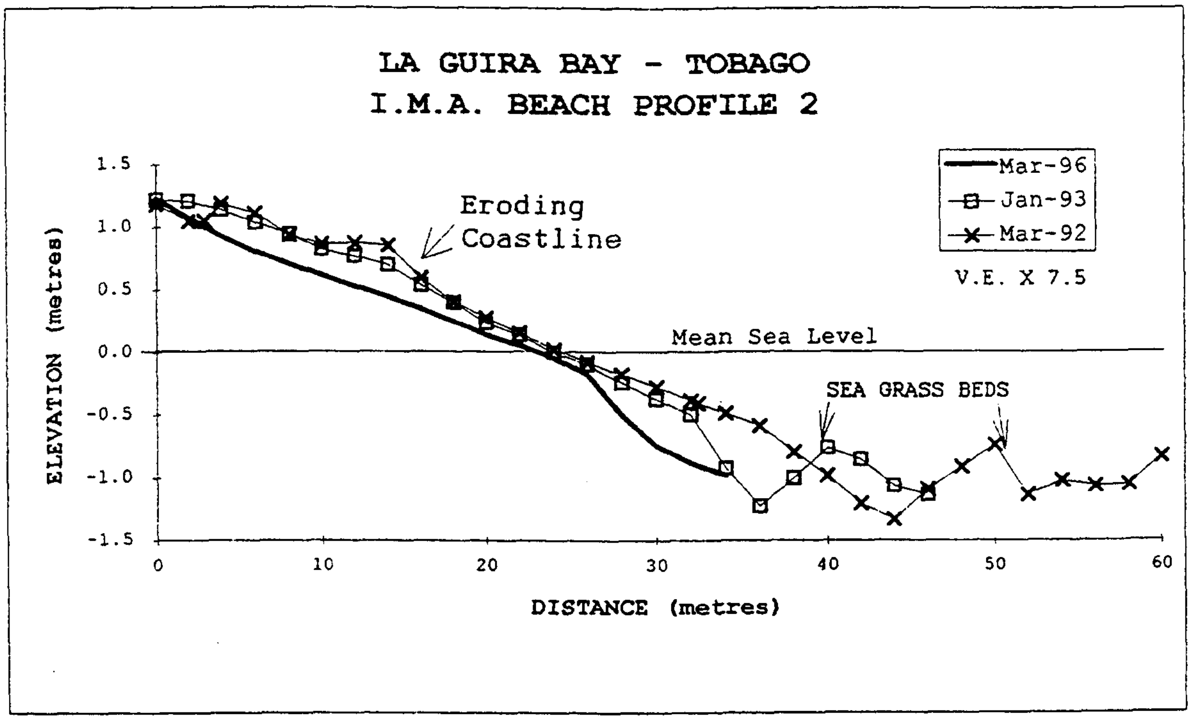
Continued monitoring of Goldsborough Beach by the IMA as part of the Coastal Conservation Project, recorded that mining continued beyond the stipulated time (May 1988) and continued to 1992. Figure 2a, which shows the results of this study, reveals that up until 1993 the beach at Goldsborough Bay showed a progressive loss of sediment. Recent field visits by the IMA in September 1996, indicated that the beach is slowing recuperating from the sand mining activities which had taken place over the last thirteen years, Figure 2a.

During IMA monitoring studies of Tobago beaches it was also observed that the beaches located in Rockly and La Guira Bays, Figure 1, were also being mined for sand and were eroding as a result of this activity. At Little Rockly Bay, Figure 1, the proposed site of a large development, monitoring studies indicated that erosion taking place at the eastern end of this beach is due to the clearing of the river mouths. Sand bars usually form across the mouths of the rivers emptying into this bay. The THA clears away sand from these river mouths on the grounds that this reduces the breeding of mosquitoes. Figures 3a and 3b show that the beaches of La Guira and Little Rockly respectively, are undergoing erosion as a result of this sand mining.

PRESENT STATUS OF SAND MINING

Based on site visits to Tobago by the IMA, together with discussions with representatives of the THA, it is apparent that some of the beaches mentioned above (Goldsborough and Turtle Beaches) are no longer being mined for sand. However, recent site visits by the IMA (September 1996) revealed that at Richmond Beach which is officially closed to sand mining, sand is still being removed from this beach. In addition, the mouths of rivers are still being cleared and the sand trucked away. A study by Oliver (1996) indicated that the integrity of several bridges located across river mouths have been threatened due to the clearing of these rivers, and many are failing as a result of this activity.

Figures 3a and 3b: Beach Profiles Showing the Changes in Beach Morphology Since Sand Mining Started.



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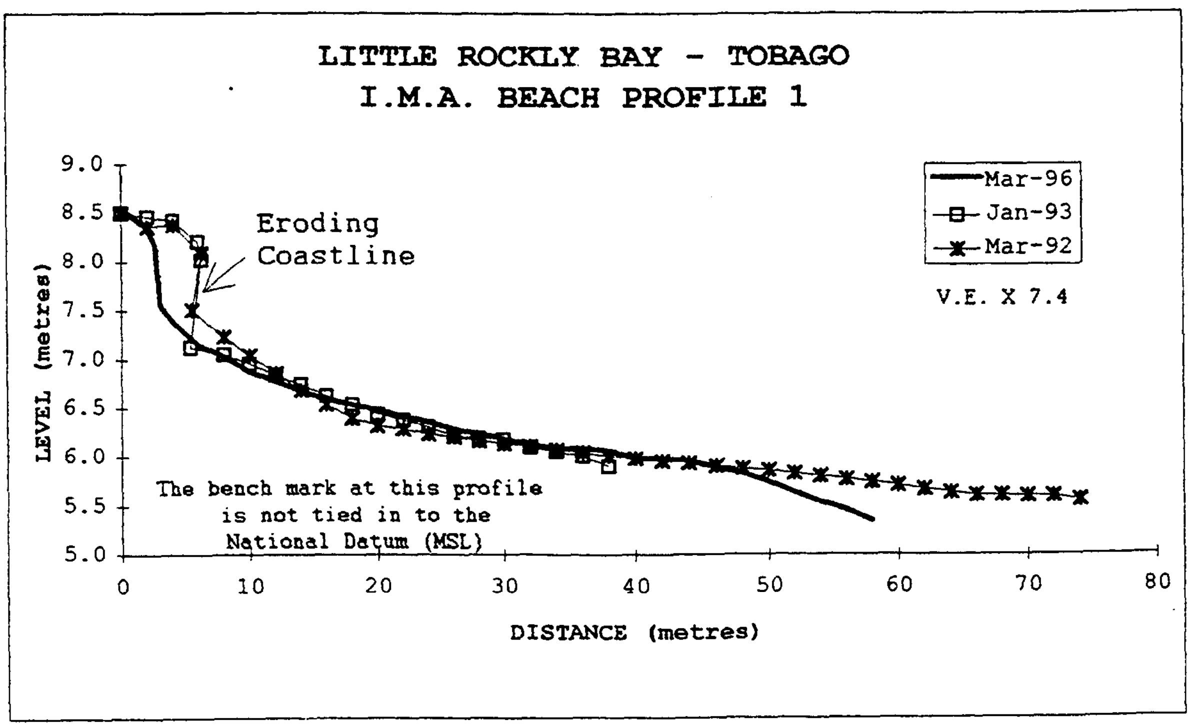

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ALTERNATIVES TO BEACH SAND MINING

Several alternatives to beach sand mining have been suggested by the Ministry of Energy and Energy Industries, Non-Governmental Organizations (NGO's) in Tobago and by a Beach Sand Mining Committee initiated by the IMA in association with the THA. The following are some options to beach sand mining which are presently being reviewed by the THA, The National Quarries Company Ltd. and the Ministry of Energy & Energy Industries (Quarries Division).

Offshore Mining

This alternative can also pose environmental problems. Dredging of sediment increases the turbidity of the water, which can impact on coral reefs and seagrass beds. There may be seabed sources of sand in the form of submerged sand banks, offshore from Tobago. However, this option cannot be considered at this time, as there is very little data on the location, quality and quantity of these seabed sand sources around Tobago. Scientific studies and environmental impact assessments would have to be undertaken before this option can be considered.

Rock Crushing at Studley Park Quarry, Tobago

The quarry/rock crushing plant at Studley Park supplies aggregate to the construction industry in Tobago. This process of crushing igneous rocks involves removal of overburden, drilling and blasting, excavating and loading, crushing and screening. This operation cost is very expensive and at present the plant cannot consistently produce the quantity and quality of sand needed by the construction industry, particularly the fine-grained sand used in the production of concrete mortar and plaster.

Crushing of North Coast Schist and Ultramafic Rocks

This option is being reviewed by the Ministry of Energy & Energy Industries. The two rock types are considered suitable because of their physical characteristics. They are severely jointed and weathered and therefore can be easily ripped and crushed without the use of explosives (Oliver, 1996). However, they are located in forest reserve areas and as such environmental impact assessments would have to be undertaken before this option can be considered.

Importation of Aggregate

Trinidad has adequate quantities of aggregate or various grades and of high quality which can be made available from the National Quarries Company Limited. Adequate quantities of aggregate of various grades are also available from foreign/regional sources - for example good quality river sands could be imported from Guyana. The importation of aggregate from Trinidad appears to be the most viable option in spite of the high cost of the aggregate and inadequate infrastructure such as marine transportation and docking facilities. At present this option is being implemented by the Tobago House of Assembly and the National Quarries Company Limited.

CONCLUSIONS AND RECOMMENDATIONS

Beaches are important natural resources of Tobago and they should be protected by the relevant authorities. The studies and site visits conducted by the IMA since the early eighties, have indicated that the beaches in Tobago cannot meet the demand for aggregate in the long or short term. Some beaches can recover from regulated sand mining, however most cannot. The authorities in the past have not shown the ability to properly regulate sand removal.

As discussed above there are other options which can be considered. It must be noted however, that all options would be more expensive to the developer, since beach sand is now treated as a "free resource". A cultural change has to take place in order to resolve this problem. Enforcement of the law to prevent the illegal removal of sand would be one direct way of forcing cultural change.

Based on these findings it is strongly recommended that the mining of rivers and beaches must not be permitted and the relevant authorities take the necessary action to ensure that this activity ceases immediately. It is also recommended that sand of high quality should be imported from Trinidad in the interim, while all the options are being carefully evaluated.

ACKNOWLEDGEMENTS

The author would like to thank the Tobago House of Assembly (THA) for the use of their data; the Institute of Marine Affairs particularly Mr. Peter Joseph the Geological Technician for preparing the figures, Ms. Charmain Pontiflette-Douglas for the typing, and Dr. Avril Siung-Chang for reviewing the manuscript.

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SAND MINING
A POSITION PAPER FROM MONTSERRAT

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Walter Christopher, Ministry of Agriculture, Trade & Environment,
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ABSTRACT

Sand mining has been an accepted tradition in Montserrat for many years, this has caused the progressive destruction of many beaches. The paper reviews the history and the attempts to control sand mining since the 1970's. It is only since Hurricane Hugo in 1989, that serious efforts to control the mining and to establish alternative sources of fine aggregate, have been implemented with some degree of success. The recreational beaches on the west coast were beginning to display the benefits of a controlled sand mining policy. The commencement of volcanic activity in July 1995 has necessitated the revision of this policy in the light of new physical conditions.

PROFILE OF MONTSERRAT

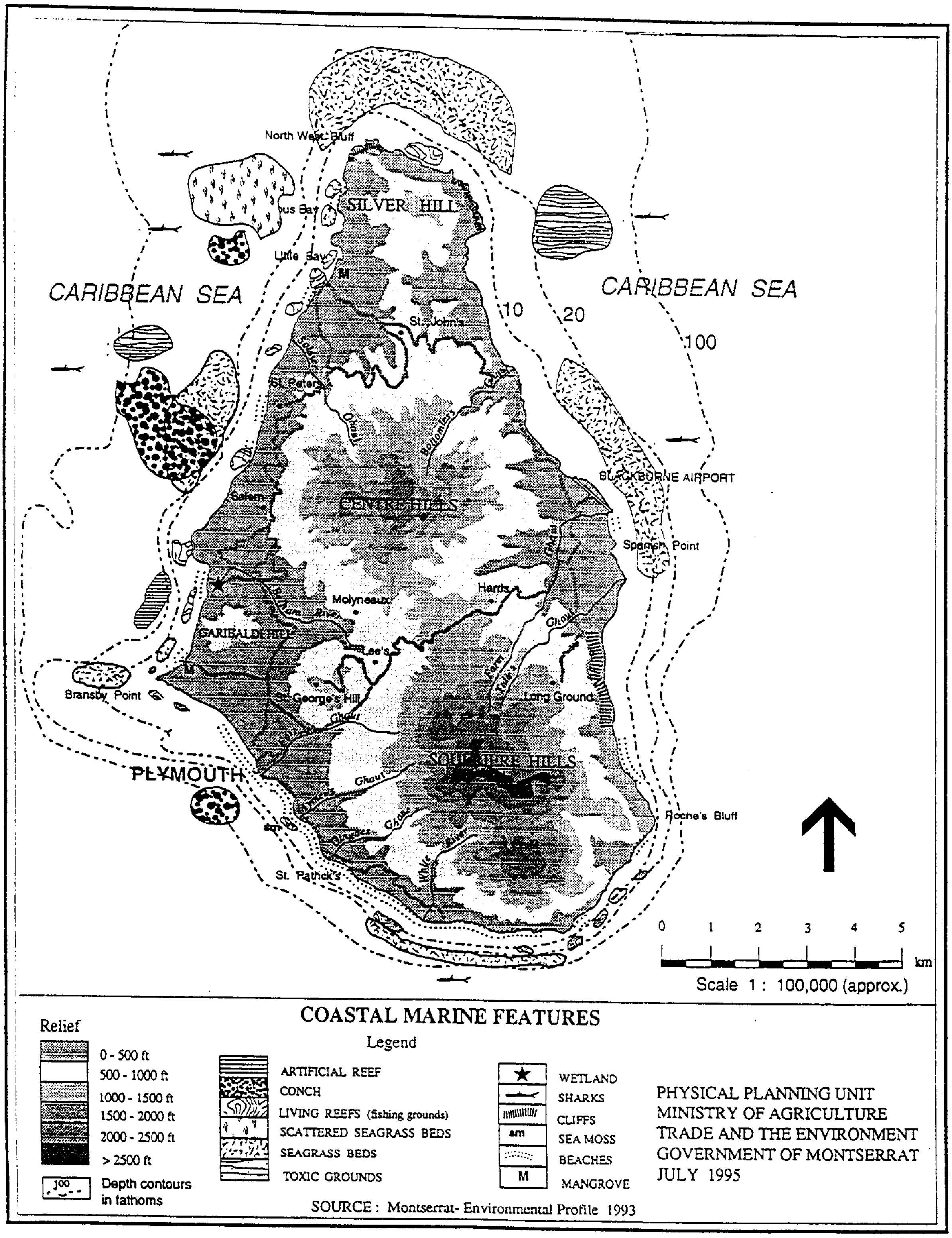
Montserrat is a British Dependent Territory located within the Leeward group of the Lesser Antilles. It is 39.5 square miles (102 square kilometres) in area, approximately 11 miles (18 kilometres) long and 7 miles (11 kilometres) at its broadest point.

The island is volcanic in origin and comprises three mountain systems - Silver Hills, Centre Hills and the South Soufriere Hills. Chances Peak which is the highest point at 3,002 feet is located within the South Soufriere Hills. The topography is typified by heavily vegetated mountains through the centre of the island, with a number of deep ghauts radiating out from the peaks to the coast, see Figure 1. The coastal strip is relatively narrow and development is concentrated along the leeward and westerly coast.

The steep topography reflects in the marine and coastal environment which is characterized by a relatively narrow coastal shelf (in some places dropping to 100 fathoms (600 feet) in less than a mile). The shoreline is rugged consisting mainly of cliffs and rocky shores. The coastline totals 28 miles (45 kilometres), of which just over 8 miles (13 kilometres) comprise beaches. With the exception of one beach in the north of the island - Rendezvous Bay, all the beaches are of 'black volcanic sand'.

At the last census (1991) the population of Montserrat was 10,639. A mid year estimate in 1993 recorded a population of 10,481. A census undertaken in July recorded a population of

Figure 1 Coastal Marine Features of Montserrat



8,069. The decline of 23% since 1993 is directly attributable to the volcanic activity which commenced in 1995.

The volcanic activity has caused the relocation of 4,051 persons into a defined 'safe area' which corresponds roughly to the northern half of the island. The capital, Plymouth, is inaccessible together with all the commercial, business, retail, health, education, recreational, community and administrative services and facilities. There have been three periods of evacuation and the current period, which commenced in April, is the longest and still ongoing.

The economy of Montserrat has been dominated by three sectors - real estate/housing, government services and construction. In 1993 these sectors comprised 12.44%, 22.27% and 10.23% of GDP (Gross Domestic Product by economic activity, at factor cost in constant 1977 prices) respectively. With the exception of government services, which has increased in value by over 50%, these sectors have performed constantly at these levels since 1977. Tourism was developing into a key growth sector in the economy. Tourism expenditure in 1993 was 35.4% of GDP. Tourism revenue was 16.4% of total government revenue. Tourism in Montserrat has been dominated by 'residential tourism'. This process involved the development of agricultural estates and their subdivision into lots for the construction of residential villas for expatriates for permanent or vacational occupation. This process commenced in the early 1960's and 1,332 acres were released for development. It has been estimated that only 37% of the lots have been developed.

Apart from community, personal and social services, construction is the major employer and 29% of the total employed labour force were employed in this sector in 1993. Although this proportion has been relatively constant over the past 10 - 15 years, it peaked in 1990 with the post-Hurricane Hugo reconstruction boom, and has declined since.

Montserrat's Public Sector Investment Programme plays a key role in the economy, particularly in the construction and real estate sectors.

In summary, construction primarily through the public sector investment programme and the residential tourism sector has, and will continue to play a significant role in Montserrat's economy.

REVIEW OF SAND MINING ON MONTSERRAT

Sand mining has been an accepted tradition in Montserrat for many years. However, the commencement of the residential tourism developments in the early 1960's and the increasing amount of public sector development created an unprecedented demand for concrete. Furthermore, the residential tourism developments introduced new materials, designs and construction techniques which reflected those in North America and Europe, from where the majority of investors and developers originated. This in turn led to the introduction of the same techniques and materials being applied in housebuilding for the indigenous population. Out of the total island housing stock 59% is of concrete construction and 82% was constructed after 1960 (1991 Census). A substantial increase in the amount of sand that was required in construction was caused by this upsurge in construction activity and the changes in methods and designs. In contrast, the traditional method of constructing in wood with concrete piers and pads was a low consumer of sand.

The majority of construction activity took place along the west coast and the mining of sand took place on the nearest beaches. In particular, Sugar Bay at Wapping, Jumbie Beach and Isles Bay were heavily mined.

Concern over the loss of sand from the beaches prompted the passing of the Beach Protection Ordinance No 9 of 1970. This Ordinance prohibited any person from using a motor vehicle for the removal of sand, stones, shingle or gravel from any part of any beach, seashore, foreshore unless a written permit has been issued by the Permanent Secretary, Ministry of Communication and Works. This procedure did not apply to vehicles owned by the government. The ordinance imposed penalties and powers to arrest offenders. The ordinance was amended by the Beach Protection (Amendment) Ordinance No 24 of 1980. The amendments were minor and did not alter the substantive provisions of the 1970 ordinance. Neither ordinances however defined what comprised the beach.

The mining of the beaches continued resulting in their progressive destruction. As a consequence it became necessary to close all the beaches on the island with the exception of Carrs Bay and Trants. The degradation of the beaches particularly those along the western coast prompted the Ministry of Agriculture, Trade & Environment (MATE) to seek assistance from the Organization of Eastern Caribbean States Natural Resources Management Unit (OECS-NRMU)in St Lucia in assessing the changes.

The measurement of beach changes along the west coast between 1966 and 1990 showed that the position of the beaches had moved inland and that the average rate of retreat was 1.05 metres per year over the 24 year period. The mean value covers a range of 0.24 metres to 2.73 metres per year.

All the beaches measured showed an erosion trend. Analysis confirms that not only had the beach width decreased, but also the land behind the beach had eroded. The reasons for the high erosion rate include the effects of two major hurricanes in 1979, and the direct impact of Hurricane Hugo in 1989 and the effects of extensive beach mining.

Coastline changes over the 24 year period were assessed using the 1970 OS 1:2500 scale maps and the 1966 aerial photographs. The 1970 map shows a very wide beach in front of Plymouth continuing north to Sturge Park. Over the 20 year period the edge of the cliff had retreated inland by between 10 and 16 metres. Undermining of Sturge Park occurred and the loss of an estimated 66,700 square metres of land along this coastal strip. It is possible that much of this reduction was due to port relocation and jetties which were constructed since 1966.

The next significant event in the history of sand mining in Montserrat was the closure of Carrs Bay in 1990, following excessive mining of sand. The result of this activity caused almost total beach loss and threatened a historic site on the foreshore and the stability of a sporting complex.

In recognition of the continuing problem and in particular the destruction caused by Hurricane Hugo, MATE appealed for outside assistance. In response, OECS NRMU held two seminars on the island. The first in March 1990 established a beach monitoring programme and as the situation continued to deteriorate, a second workshop was held in November 1990 to review the position on sand mining. At the November workshop representatives of the Ministries of Communication and Works and Agriculture, Tourism, truckers, contractors and the Montserrat National Trust participated.

The outcome from the second workshop was the adoption of two goals:

1. A short term goal such that beaches would be closed to sand mining by February 1, 1991 and crusher dust and imported sand would be substituted for beach sand in construction.
2. A longer term goal, whereby all sources of fine aggregate for construction would be investigated, and the most suitable sources for Montserrat would be identified and utilized for construction.

Sand mining continued however, and in April 1991 the Government's Executive Council (EXECO) resolved that barriers should be erected at Foxes Bay and Little Bay to prevent trucks from going onto the beach to remove sand. The closure of the last beach - Trants, was delayed beyond the February 1 deadline because a source of imported sand at a workable price and sustained supply could not be identified.

At this time a modern quarry became operational in Montserrat. This enabled the local provision of aggregate for the construction industry. The quarry has a vast reserve of material for extraction. With an alternative source available Executive Council took a decision early in 1992 to close the beach at Trants, thereby making it unlawful to remove sand from any of the beaches on Montserrat.

From May 1992 attempts were made to utilise crusher sand from the quarry for concrete blocks, plastering and structural works. Crusher dust was initially offered at EC$50 per cubic yard, although it was immediately reduced to EC$35 per cubic yard following a public outcry.

In July 1992, a Government Research Study of the cost of construction concluded that the price of quarry sand and its quality were cause for concern. It was found:

1. that the quarry dust or sand was of poor quality compared to the beach sand, and presented a difficulty for users, especially in plastering;
2. the quarry dust or sand was too expensive at EC$35 per cubic yard;
3. that in the long term the use of quarry dust instead of beach sand could provide a cost saving to the builder. For example, salt in beach sand causes the reinforcement in concrete buildings to corrode and shortens the life span of buildings. In addition, the salt content of the smooth plaster causes paint to eventually peel from walls.

The government commissioned a further study, which concluded that for a house which cost EC$100,000 and required 38 cubic yards of sand, the cost differential for quarry sand over free beach sand was 1.2%. However, quarry sand was perceived to have a number of disadvantages. The sand was said to require more water in order to improve workability and, as a consequence, a small increase in cement was necessary to maintain strength requirements. The high soil content in the aggregate used for plastering was also said to cause plaster shrinkage and cracking.

An education campaign was launched to inform the public of the efficiency and effective use of quarry sand and dust. It was also recommended that the quarry undertake a regular programme of testing to ensure that the crusher dust was maintained at the optimum standard.

After much political pressure, on October 8, 1992 government mandated MATE and the Ministry of Communication and Works to form a committee with the task of reviewing the issues as they related to sand, crusher dust and training, and to overcome the problems that existed.

The follow-up to this was that in February 1993 EXECO decided that beach sand would be available from Farm's Beach for a six month period. The sand was to be available for plastering only via a permit system administered by the Building Inspector. The sand was initially stockpiled at the quarry who in effect were selling the sand for Government. This arrangement lasted for three months and resulted in public opposition. Consequently, the stock piling was undertaken by the Public Works Department under supervision of MATE.

During the period between February and July 1993 plastering trials using quarry sand were undertaken, and in July the Public Works Department concluded that a 1:4 mix was acceptable for both interior and exterior plastering.

In April 1994 EXECO decided to fully open Farm's Beach and to make beach sand available to builders under a permit system administered by the Physical Planning Unit. Two beach wardens were employed for three days per week to police the movement of sand during normal working hours. Beach sand costs EC$10 per cubic yard. The sand is loaded manually.

Since the introduction of the permit system the following quantities of beach sand have been extracted:

Year	No. Of Permits Issued	Cubic Yards of Sand
1993 (5 months)	56	291
1994 (8 months)	121	1022
1995 (7 months	86	631

Source: Physical Planning Unit

The permit system is administered by the Building Inspector who assesses the request to extract sand on the basis of the type of building construction and the stage reached. The application form requests planning approval number, location, vehicle to be used in carrying the sand and registration number, applicant and amount required. A permit is then issued on payment of the requisite fee and a copy of the permit sent to the site warden.

A review of the system was undertaken by the Physical Planning Unit following concerns that sand was being extracted without a permit and outside the normal working hours and that government departments were able to extract sand without submitting applications to the PPU. A proposal for tightening up the process was recommended to limit potential abuses. This included more information on the application e.g. floor area of the building, and the introduction of an application form. These new procedures were not, however, introduced.

The Montserrat Building Code & Guidelines were also progressed to a final draft stage in 1994, and at present require that sand to be used in construction must be 'clean, natural sand, preferably taken from an inland source as the use of beach sand will not be allowed'. The Building Code and Guidelines are at present going through a final consultative review stage and it is likely that this particular requirement will be amended.

During 1994, a new act, the Beach Protection Act 1994, was drafted. This sought to tighten up and clarify the legal provisions, particularly in respect of what constitutes the beach, and to up-date powers for enforcement. This act has not been enacted.

Farm's Beach is located within the unsafe area and with the advent of volcanic activity has been unavailable for legal extraction. However, extraction has continued on an ad-hoc and uncontrolled basis. The unavailability of access to the designated beach has also led to indiscriminate extraction at other beaches on the west coast. Although this has not been a frequent occurrence, it does demonstrate how precarious the balance is between controlled mining and a free-for-all. The likelihood is that as Montserrat moves into a phase of major construction and development in the safe area in response to the volcanic situation the demand for beach sand will increase. The quarry although bordering the unsafe area has continued to operate during the volcanic crisis.

Beach monitoring as it relates to sand mining started in February 1990 and was incorporated into the COSALC programme in 1994. Regular monitoring continues up to the present day.

An overall assessment of the programme is done annually and the data analyzed using version 2 of the Beach Analysis Software.

The programme was instrumental in the formulation of a sand mining policy. Additional profile sites were added in July 1995.

The conclusion from the first monitoring phase was that 'the recovery phase (following Hurricane Hugo) is now over........Against this background it is especially important to continue to control beach sand mining and to promote other materials such as crusher dust.'

In summary, Montserrat's beaches never had a formal management strategy until February 1990 when the COSALC monitoring programme commenced. As construction activity grew in economic importance, the island's beaches have become more and more vital to the economy, and although the use of beach sand is extremely destructive, significant growth in the late eighties and into the nineties in the construction sector, has made beach sand a valuable commodity.

As a consequence, the Government introduced a ban on all sand mining from the beaches. However, in 1993 one beach was opened for sand mining - Farms Beach. This decision was influenced by the results of the beach monitoring exercise which indicated in 1992 that beaches were showing signs of replenishment following indiscriminate mining and the ravages of Hurricane Hugo. The exception was one east coast beach which had been heavily mined during the post-Hugo period.

The permit system which has operated since 1993, has effectively led to a cessation of sand mining on other beaches. Since the 'approved' beach is located on the windward side of the island, the popular recreational beaches on the leeward side of the island have therefore been protected.

The commencement of volcanic activity in July last year has resulted in Farm's Beach being inaccessible for controlled sand mining. As a consequence, incidents of unauthorised mining on beaches in the 'safe area' have been recorded, often involving government departments or the utility companies.

Despite a controlled sand mining policy which was beginning to display benefits for the leeward recreational beaches, the volcano situation has demonstrated how precarious the system of control is and how the perceptions of both private and public sector agencies remain unchanged in regard to the accessibility of beach sand.

Beach changes are monitored on a regular basis, although this data is not fed into the development of management policies for the beaches.

THE ISSUES FOR MONTSERRAT

The issues that are facing Montserrat in its continued formulation of a position on sand mining are firstly to determine to what extent capacity exists at Farm's Beach to sustain sand extraction. This is critical given the possibility of a substantial increase in construction activity within the safe area in response to the volcanic crisis. This problem is compounded by the location of Farm's in the unsafe area.

Secondly, although beach changes have been regularly monitored and there is a good understanding of the impact of hurricanes and sand mining on beach profiles, this information is not utilised to any great extent in the formulation of management or development control policies e.g. setback guidelines etc. Furthermore data is not integrated into the physical planning process and the tools, such as GIS, that are available to assist in physical planning do not incorporate beach monitoring data.

Thirdly, the monitoring programme should be sustained because the data is so critical to understanding changes, either arising from hurricane damage or from sand mining, and has provided the basis for the formulation of the Government of Montserrat's sand mining policy.

Fourthly, the legislation needs to be up-dated and in particular, the definition of beach, foreshore etc. clarified. Similarly the Montserrat Building Code and Guidelines will need to adopt a clear position on the use of beach sand.

Beaches on Montserrat offer many benefits, and so, if there is to be a fair sharing of the benefits offered by the beaches, steps must be taken to plan and manage them so that they can be enjoyed by all.

SAND MINING IN THE BRITISH VIRGIN ISLANDS - A SECOND LOOK

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ABSTRACT

This paper discusses the history of sand mining in the British Virgin Islands. Between 1982 and 1996, 13,624 cubic yards of sand were legally mined from the beaches. Josiah's Bay and Fat Hogs Bay were the most heavily mined beaches, the latter beach was almost completely mined out. The Beach Protection Ordinance of 1985 has been used, somewhat unsuccessfully to control beach sand mining. It is suggested that the Mining Act of 1980, which controls the commercial mining of minerals and specifically addresses restoration and the charging of royalties, would be a better mechanism for controlling sand mining. The paper further suggests that there are adequate sand supplies in the coastal valleys behind the beaches which could supply building aggregate long into the future.

BACKGROUND

> "Ironically, developing countries are still repeating the mistakes of the developed nations when it comes to coastal management. Although developed countries are now replenishing beaches, much of the world continues to emulate their economic policies that contributed to beach destruction. Beach sand and gravel mining, followed by the archaic response of building seawalls and groins to solve the resulting erosion problems, is not in the best interest of any national economy. Did technology transfer end in the 1970's? Are sound coastal management policies guarded secrets?" (Neal & Pilkey, 1992).

In 1981 the British Virgin Islands (BVI) was in the middle of a tourism boom and there was a need to assess the status of the beaches, and the impact of sand mining and coastal development. A student intern carried out the first analysis of the characteristics of the beaches of the BVI for the Town and Country Planning Department (Lettsome, 1982). Beaches have been identified as a critical natural resource, as they play an important role in tourism, and in coastal protection. The economics of beaches have been a major driving force in shaping the policies as they relate to beach management and development in the BVI. As the Territory developed, the need to protect beaches as a part of the tourism product, for recreation, fisheries and coastal protection, surpassed the need for mining sand for construction purposes. The short term benefits and long term cost of sand mining, the increasing value of beach front property, and the long-term benefits of sound beach management and development for recreation and tourism, all played a part in changing public opinion and tolerance of sand mining.

BEACH MONITORING IN THE BVI

In January 1984 an Amherst College geology team conducted the first study of the geology and characteristics of selected beaches of the BVI for the Town and Country Planning Department(Belt & Foose, 1984). Detailed studies on sixteen beaches on the islands of Tortola, Beef Island, Virgin Gorda, Peter Island, Sandy Cay and Anegada, provided much valuable baseline data and initiated the scientific study of our beaches. Physical and geologic settings, climatological data, mapping, establishing beach profiles, examination of vertical beach sections, composition of sand, textural analysis, grain size analysis, interpretation of the geologic history, calculation of the amount of sand in each beach system, sources of stress, and alternative sources of construction materials, were documented.

In September 1984 the Conservation Office was established within the Ministry of Natural Resources and Labour with beach management and development as one of its responsibilities. In August 1985, the 1961 Beach Protection Ordinance (Cap 208) was repealed and replaced by the Beach Protection Ordinance 1985. This new ordinance for the first time afforded legal protection to all beaches throughout the Territory from: fouling of the foreshore, mining and removal of any deposit of sand, stone, gravel, or shingle, and the removal of any natural barrier. In 1986 technical assistance was sought from the Organization of Eastern Caribbean States in the areas of review and strengthening of coastal legislation, and administrative guidelines for institutional strengthening for coastal zone management.

In 1989 the Conservation Office and Fisheries Office were merged and the Conservation and Fisheries Department was formed. Beach management and development was upgraded to a full programme area of the new department. In February 1989 the COSALC project was initiated under the beach management and development programme of the Conservation and Fisheries Department. Conservation and Fisheries Department technical report #21 documents the beach changes in the BVI between 1989 and 1992 (Cambers *et al*, 1993). In May 1994 a joint Amherst College/University of South Florida Geology team revisited the beaches of the BVI. A total of 18 beaches in the Conservation and Fisheries Department monitoring programme on the islands of Jost Van Dyke, Tortola, Beef Island, Virgin Gorda, and Anegada, were surveyed, and a laser-beam theodolite equipped with a computer notebook for rapid automated processing of the data was used to measure the profiles (Belt *et al*, 1994). Since mid 1994 the Conservation and Fisheries Department has been working closely with the Survey Department and the Town & Country Planning Department to upgrade the beach monitoring programme.

All the reference sites on all the islands, except Anegada, have already been tied to the survey grid and permanent stations have been established. Conservation and Fisheries Department personnel are being trained in the use of the laser-beam theodolite and the database is being established so that profile and other beach survey information can be stored, processed and used in our geographic information system. Parameters monitored will be expanded to include tidal variations, currents, wind data and wave height; the number of profiles per beach will be increased. In addition, four representative beaches will be chosen and studied in depth with profiling being done weekly. That is the positive side of what we have been doing and are trying to do in the BVI with our beaches.

HISTORY OF SAND MINING

During the period, 1982 to 1996, the BVI legally permitted the mining of 13,624 cubic yards of sand from our beaches. The Development Planning Unit's records showed that 30,000 cubic yards of sand was imported into the Territory annually over the last five years. Sand is being sold for $35.00 (US) a cubic yard as compared to $25-28 per yard for gravel. This underscores the fact that sand is a very important resource and demands appropriate management.

In 1996 as part of the environmental component of the IDP project the Conservation and Fisheries Department carried out a review of sand mining permits issued by the Minister of Natural Resources and Labour under the Beach Protection Ordinance from 1982-1996. An analysis of these finding presents a very disturbing overview of the level of beach sand mining legally permitted in the BVI during this 15 year period. It must be stressed here that the quantities recorded in this presentation are only for permitted sand mining activities and do not include or reflect illegal sand mining activities occurring in the BVI. It should be further noted that sand mined by eight dredging operations, and one unlimited beach sand mining permit, are not a part of this total. 13,624 cubic yards of sand were legally mined from the beaches of the BVI from 1982 - 1996, see Table 1 and Figure 1. This averages 908 cubic yards a year.

A total of 15 beaches have been mined, however, Josiah's Bay, Fat Hog's Bay, Brewer's Bay and Cane Garden Bay on Tortola and Little Bay on Virgin Gorda have been most heavily mined, accounting for a combined 94.4% of permitted activities. Josiah's Bay was first in mining activity with 10,051 cubic yards or 73.8%. Fat Hog's Bay second with 1350 cubic yards or 9.9%, Little Bay third with 600 cubic yards or 4.4%, Brewer's Bay fourth with 446 cubic yards or 3.3% and Cane Garden Bay fifth with 419 cubic yards or 3%.

No permits have been issued for Cane Garden Bay since 1986 when 15 cubic yards were taken. Over the last 10 years, Cane Garden Bay has developed into one of the top tourism and recreational beaches in the Territory and sand mining has ceased. As Brewers Bay beach has developed, sand mining has steadily decreased; between 1991 and 1994, 15 cubic yards were permitted and there have been no permits issued since 1994, see Figure 2. At Little Bay, Virgin Gorda a 300 cubic yard permit was issued in 1990 and in 1991. There has been no further mining permitted since 1991. No mining activities have been permitted at Fat Hogs Bay since 1992 because there is nothing left to be mined, Figure 3. The beach has been totally destroyed and over 100ft of coastline has been lost to erosion. In 1995 a coastal restoration project to reclaim the coastline at Fat Hogs Bay was started and is ongoing.

Figure 1 Review of Sand Mining Activities (Volume of Sand Mined 1982-1996)

Location	Year														
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	Total
Josiah's				1992	240	50		40	75	1450	1400	1000	500	1804	1500	10051
Brewer's		32	144	104	88		40		22	3			12			445
Fat Hog's		240			810	250					50					1350
John Tartar													50			50
Little Apple					3											3
Cappoon's				16	49		16									81
Trunk					40											40
Brandywine		80	50													130
Carrot						160										160
Trellis					64											64
Little Bay									300	300						600
Cane Garden	328	32	44		15											419
Long Bay				32	144											176
Sandy Ground				55												55
Total	408	304	238	2199	1453	460	56	40	397	1753	1450	1000	562	1804	1500	13624

Table 1 Review of Sand Mining Activities 1982-1996 (Summary)

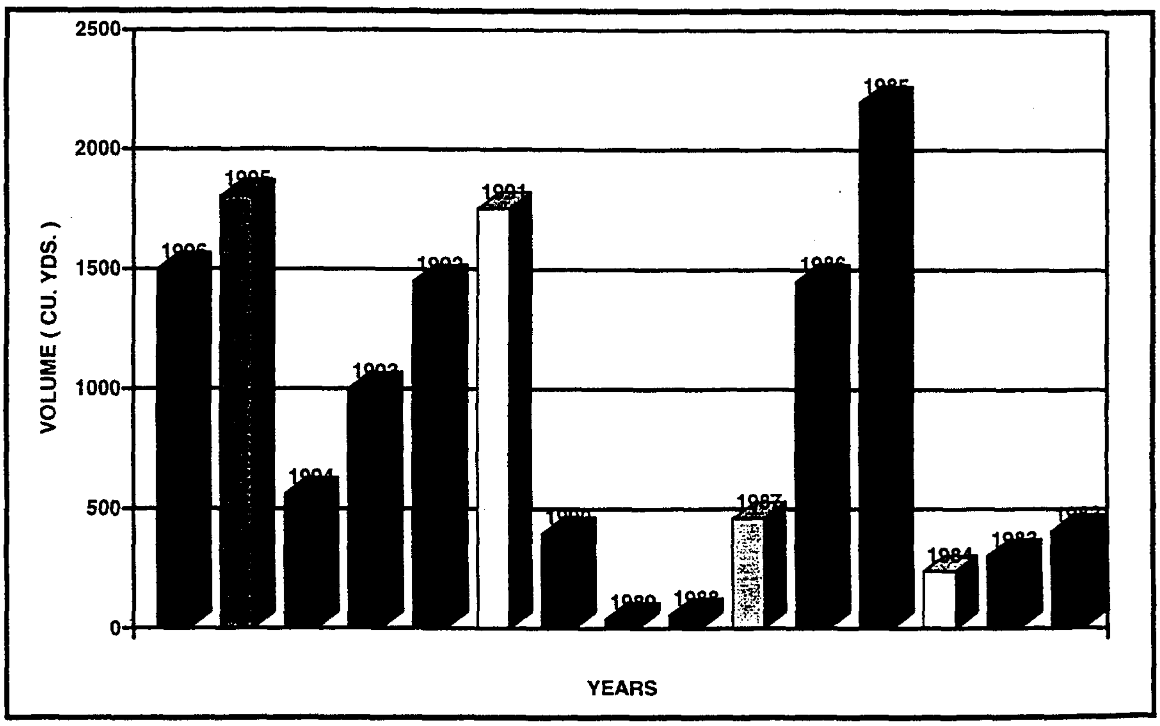


Figure 2 Sand Mining Activities at Brewers Bay, 1982-1996.

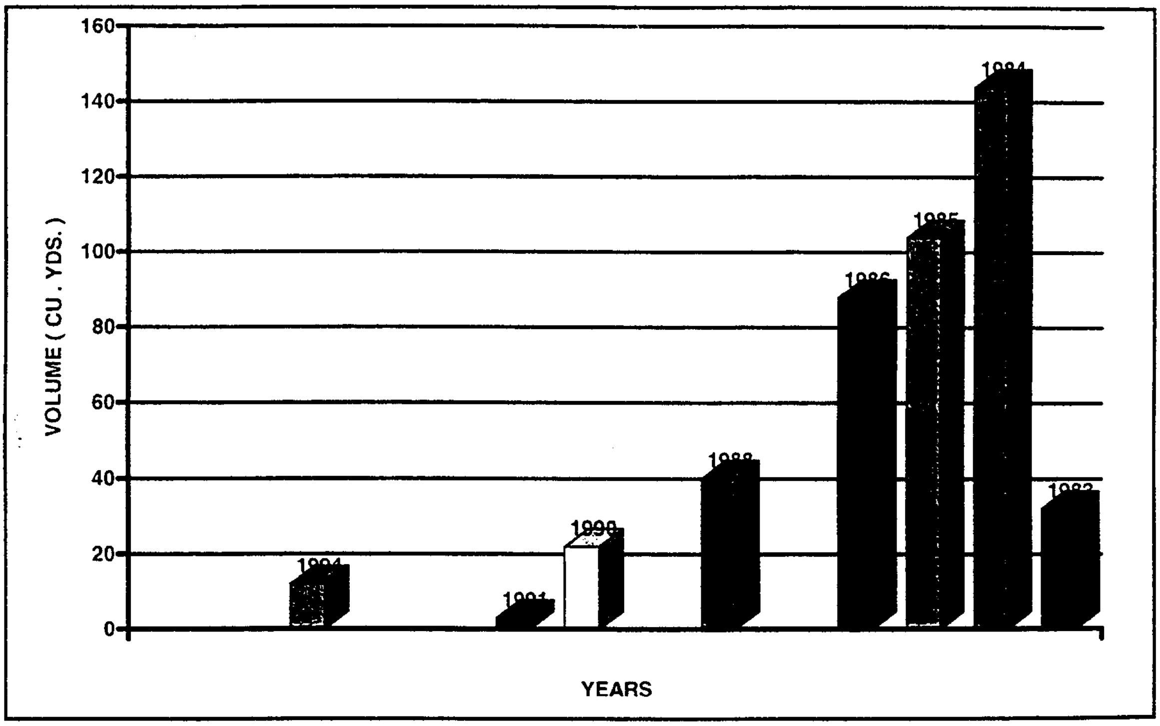
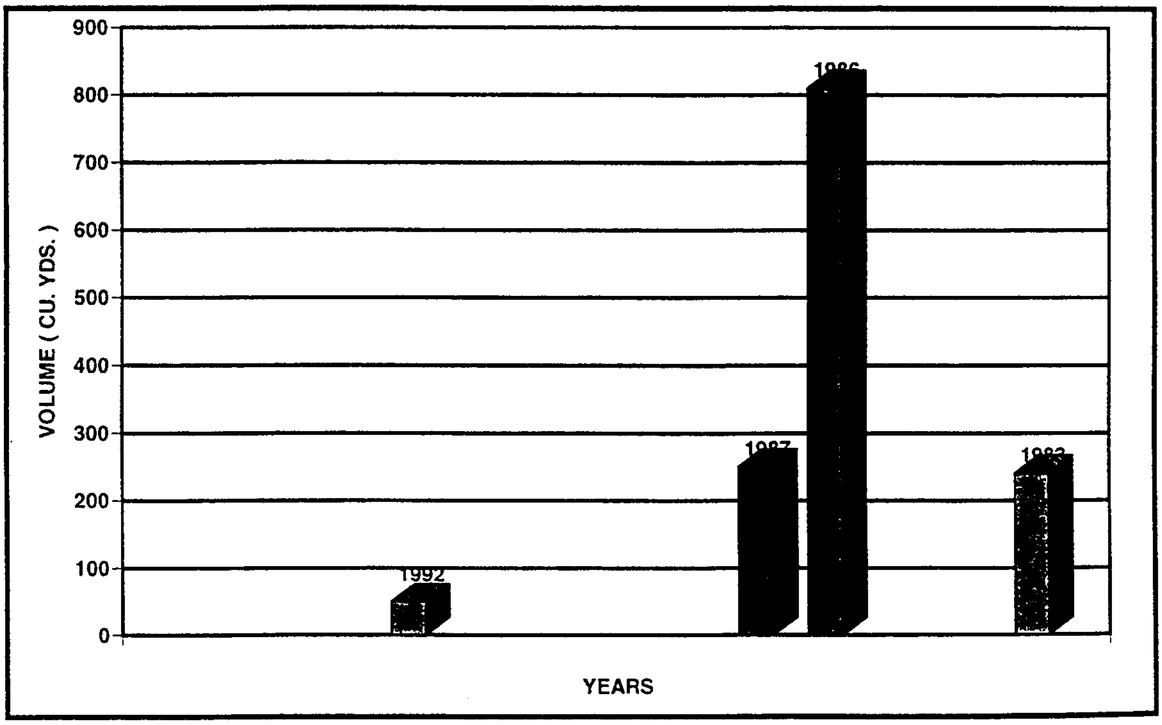


Figure 3 Sand Mining Activities at Fat Hogs Bay, 1982-1996.

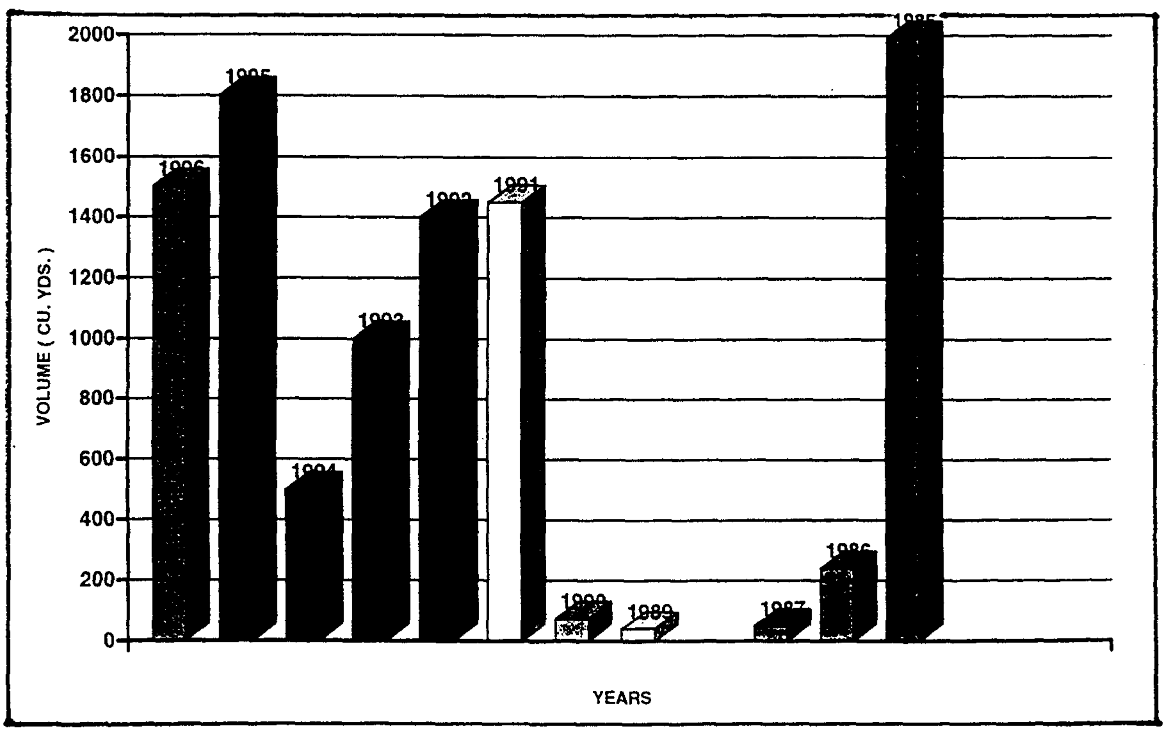


At Josiah's Bay the entire dune system has been destroyed by the massive amount of sand that has been mined, Figure 4. After over twenty years of persistent sand mining at Josiah's Bay, there is finally a move afoot by the landowners to end mining and restore the beach. Again this is largely due to economics, as Josiah's Bay has been identified as an alternate beach site for cruise ship passengers and a number of development projects geared at servicing the industry have commenced, or are in the planning stages.

One practice has been to mine the ghut or pond mouth area of the beaches. This has been a very bad choice because these storage areas are normally breached by ground swells, storm surge and flood runoff. During this process the sand is put back into the active system and is redistributed on the beach. Therefore mining of the pond and ghut mouth accelerates the erosion rate.

Land ownership is also a problem. Much of the ponds and sandy areas at the back of the beach are privately owned and people feel they have the 'right' to mine their property.

Figure 4 Sand Mining Activities at Josiahs Bay, 1982-1996



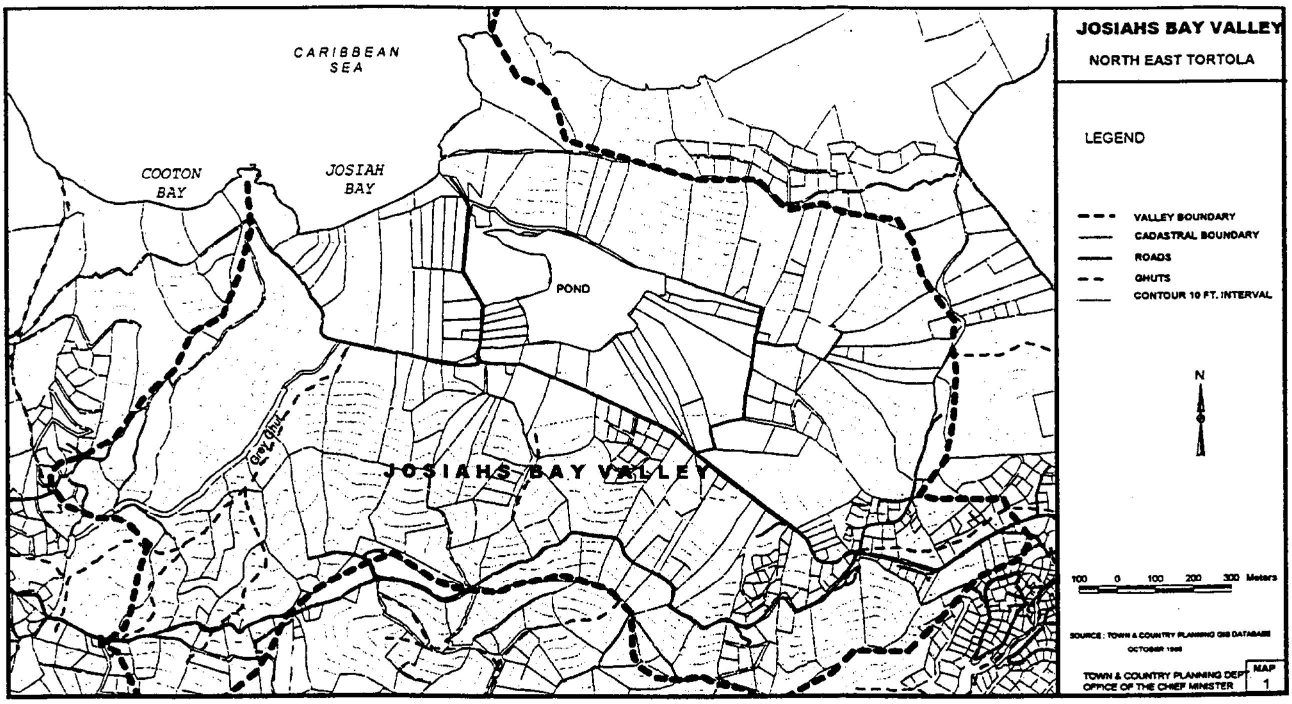
THE CASE OF JOSIAH'S BAY

In addressing the management of this very critical resource the physical and the legal issues involved at one important site, Josiah's Bay, will be discussed.

Physical Factors

Figure 5 shows Josiah Bay, a north shore valley on Tortola comprised of 620 acres (25,813 hectares), 134.4 acres of this area is flat. This represents approximately 34 acres of sand with depths of 6 or more feet. It is bounded by hills on all sides except the north or sea side. The 1400 feet long beach is protected by the two headlands and behaves as a cell, independent of other bays except during heavy winter swells or hurricanes when the shelf operates as a continuum.

Figure 5 Josiahs Bay Valley



As a cell the bay is made up of the following parts, see Figure 6 :

- the shelf
- the nearshore zone
- the surf zone
- the beach face

- the berm area
- the back beach
- the valley.

Sand is found in all these areas. It extends into the valley for about 1000 feet (350 meters) in some areas. The various parts of the beach are grouped into the following three zone, see Figure 7:

- the active zone,
- the transitional zone,
- the storage zone.

The active zone is comprised of the surf zone and the beach face. Here the water and the wind are active and the sand is affected by them.

The transitional zone is the area of vegetation - on land there are grasses, weeds, grape trees, almond trees and other salt tolerant plants; in the sea are sea grasses and algae. Here the sand is trapped and accumulation begins. This is the stabilization zone which acts as a protector of the beach. This edge with the active zone is critical to recreation. Disruptions in this area make the total system vulnerable to the forces of nature, especially wind and water.

Sand in the storage zone was previously part of the dynamic system. Sand in this area cannot get back to the active zone. Activities in this area have little or no impact on the beach system. This zone is treated as land, it is ready for built development. Once used, the sand resource under it will be sterilized and/or lost to use by man. Figure 8 shows the storage zone at Josiah's Bay.

It is in this area that sand needs to be looked at and its availability for use assessed. There is the need to determine the exact limits of this area with special emphasis on its interface with the transitional zone. Once this interface is identified setbacks from it may be determined and areas identified for built development. Prior to built development measures should be put in place for the mining of usable sand. Limits with respect to depths to be mined and type of material to be used in restoration will have to be determined as they may impact on drainage, aesthetics, etc. These conditions do not however negate the use of sand from the area identified as the storage zone.

Figure 6 Typical Beach Profile Showing Component Parts in Relation to High and Low Water

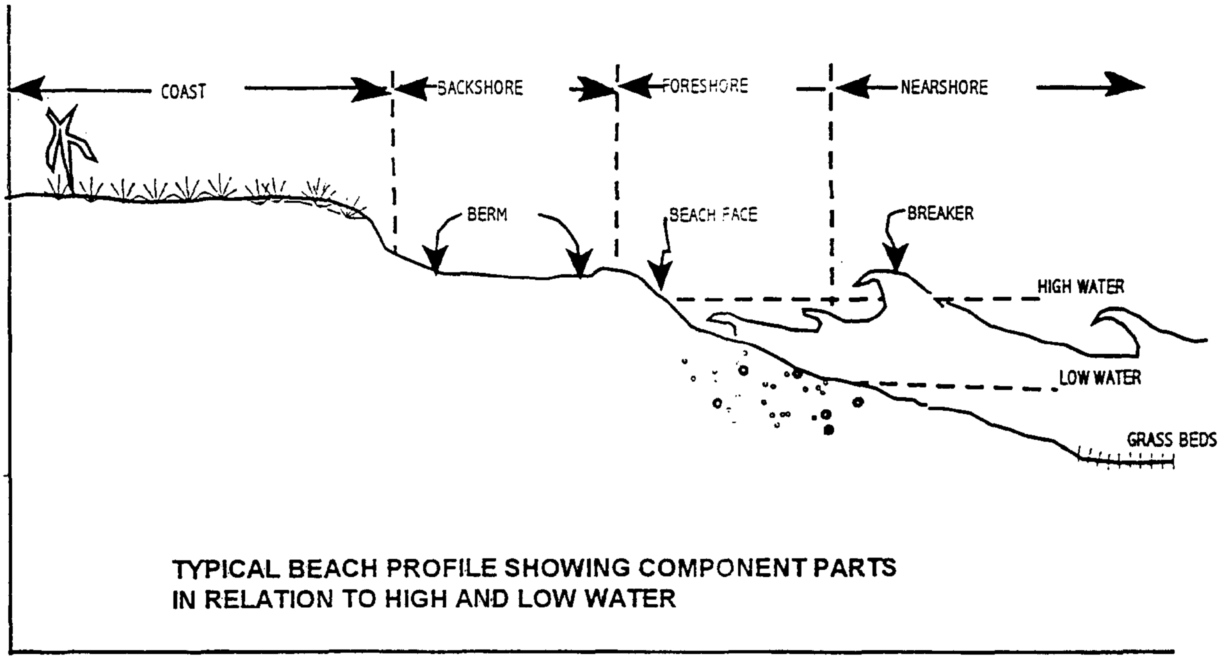


Figure 7 Beach Profile Zonation

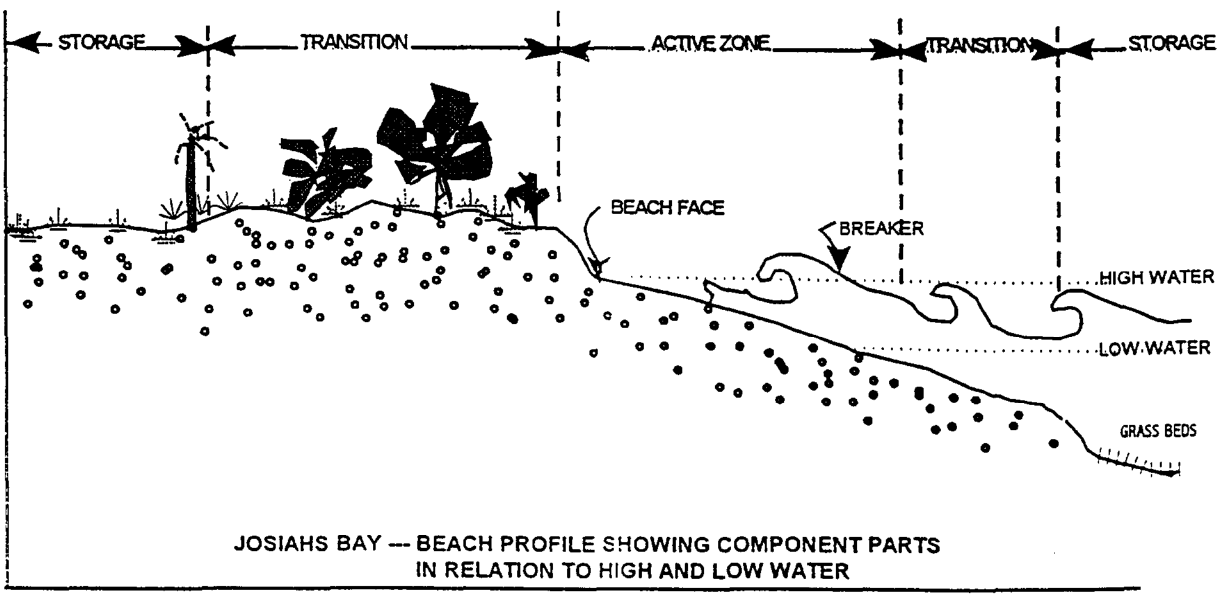
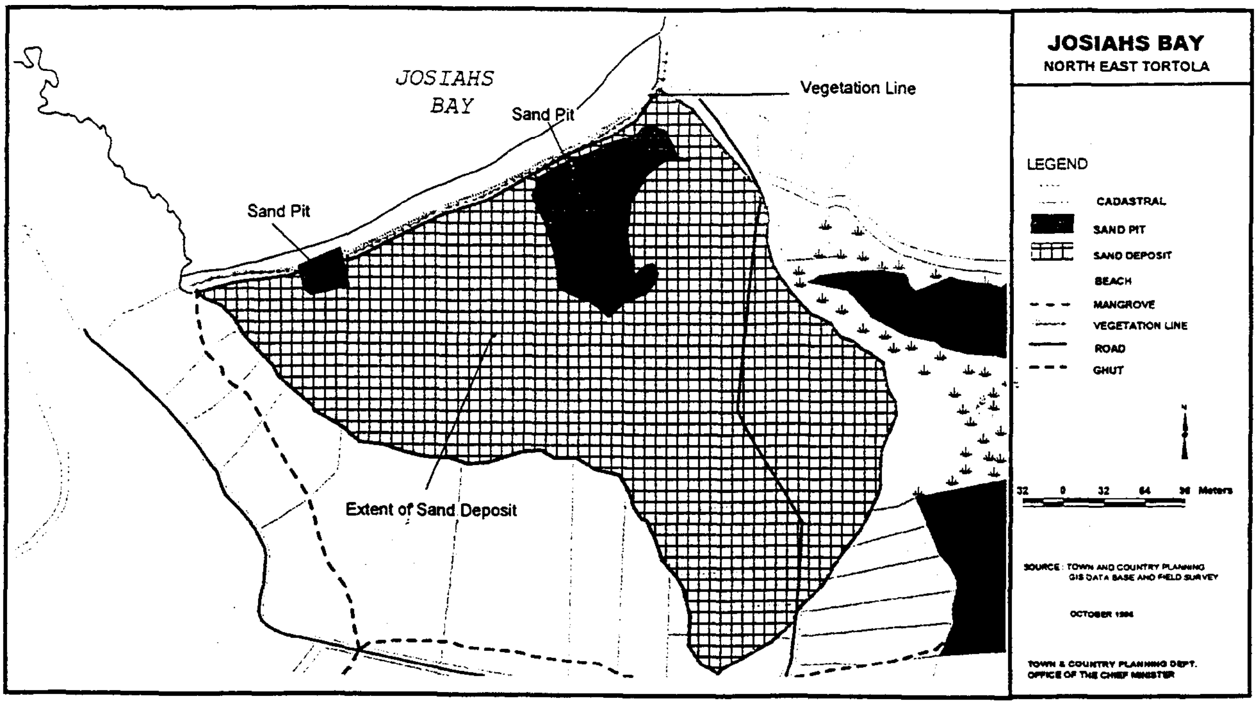


Figure 8 Storage Zone at Josiahs Bay



Legal Mechanisms

If we examine the legal mechanisms for the harvesting or mining sand we will see that there are two main ones available in the British Virgin Islands:

The Beach Protection Act of 1985 -

2. (l) Subject to section 5, no person shall-

(a) remove or assist in the removing of any natural barrier against the sea; or

(b) dig and take away or assist in the digging and taking away of any deposit of sand, stone, gravel or shingle from land that is part of the foreshore,

in the Territory except under the authority of a permit granted him by the Minister in writing in such form as the Minister approves.

(2) Without affecting the operation of subsection (1), no person shall in the Territory, remove from any land (whether the title thereto is vested in himself or

otherwise) any deposit of sand, stone, gravel or shingle if the removal thereof is likely to result in inroads being made into that land or any other land, by the sea.

The Mining Act of 1980 -

Section 5 (l) No person shall in the British Virgin Islands conduct any reconnaissance for, prospect for, or mine any minerals except under the authority of a licence issued under and in accordance with Part IV.

Nothing in this Ordinance shall prevent -

a) any person from taking, subject to such conditions as may be prescribed by the Minister, building materials for the construction of any dwelling-house, factory, workshop or store including the outbuildings or appurtenances thereof on land occupied by him under any title over or interest in such land;

b) any person engaged in construction of tunnels, roads, dams, aerodromes, and similar public works of an engineering nature or for agricultural purposes, from utilizing such building materials derived from such other sources as the commissioner may from time to time approve.

(Revised Laws of the Virgin Islands, 1991)

The Beach Protection Act as the name implies was created to stop destruction of the beach. Specifically the area referred to here as the active zone. The problem was that persons were removing sand from the beach face, or in such a way as to eventually impact the beach face; and there were immense negative impacts on the affected beaches such as:

a) Coastal erosion,
b) Unsightly scars in beach surface,
c) Loss of adjacent privately owned down stream land by erosion.

In an effort to combat this, the Beach Protection Ordinance was developed. The main point in this legislation is that: "no removal of sand was permitted from a beach without a permit from the Minister of Natural Resources." It failed to address the issue of the commercial user or the supplier, who must fill orders on short notice.

The Mining Act of 1980 addresses mining of minerals, but for some reason sand is not specifically mentioned as a mineral. This raises a question about its applicability to sand mining, although the Act does speak about conditions that may be prescribed by the Minister. The features that makes the Mining Act suitable for any commercial type operation is that it specifically addresses the following :

- An operations plan,
- Restoration after operation,
- Provision for the charging of royalties.

In summary the legislation which is put in place to protect beaches is:

a) Limited in scope i.e. all areas which need to be considered for sand mining are not addressed,
b) Sand mining is not directly included (Mining Act only),
c) Off focus as they appear to be protective, in that destruction of the beach is emphasized, rather than sand mining as a business venture,
d) Negative rather than proactive.

SAND MINING IN THE BVI - A SECOND LOOK

The Beach Protection Act addresses the active zone of the beach, an area where commercial sand mining should not take place, thereby making its applicability questionable. On the other hand, the Mining Act addresses commercial operations, which are the dominant type of sand mining operation in this country. The situation is - if someone wants to purchase sand they go to an operator/supplier. The supplier delivers the sand to the individual and collects his money. The persons actually mining the sand represent a very small number. Thus a permit specifying the number of loads he can take during a limited period of time is not the most applicable approach for controlling sand mining. A Mining License with respect to a quarry pit with the rights to mine on demand is critical.

There is the need for a number of measures to be put in place if sand mining is to be properly carried out and monitored. As indicated above :

1. The Beach Protection Act is meant to protect beaches and addresses the beach face and the berm area or what has been referred to in this paper as the Active Zone

2. Sand mining, especially for construction material, should not be considered in this zone and the legislation needs to state so explicitly. This position is supported by the Committee on Coastal Zone Management of the United States National Academy of Science, 1990.

The Mining Act is the most appropriate vehicle for the control of sand mining in the BVI, however, this Act needs to be amended to reflect the following:

1. To include provision for sand mining.

2. To detail requirements for domestic and commercial mining.

3. To indicate where such mining should take place, and I am suggesting that it should take place in the area which I have identified as the **storage zone.**

4. That all proposals for sand mining should include explicit indications of the type of mining to be carried out as well as provisions for restoration.

5. That before any building operations takes place in a sandy area that the sand in the area must be removed. The proposals for the removal of the sand to be detailed and subject to approval of the relevant agencies.

6. That the granting of licenses should be part of a process which includes consultation with all of the relevant agencies - Conservation and Fisheries Department, Town and Country Planning Department, Public Works etc.

7. That any deviations from the above require permission from the Minister and the Development Control Authority.

CONCLUSIONS

The history of sand mining in the BVI has shown that uncontrolled sand mining always causes erosion, it compounds and accelerates the erosive effects of nature. While an effective monitoring programme and good baseline data are essential tools for the initiation and maintenance of a beach management programme, it should be clear that beach sand is not the answer for construction aggregate. No removal of beach sediment should be permitted for any purpose. Enforcement of the Beach Protection legislation is a function of policy, economics and development pressures. It has not protected all beaches from sand mining.

Sand is a very costly resource and as such it should be managed appropriately. Protection Legislation is not a substitute for Mining Legislation with respect to sand. Over the years the application of the wrong tools has aided in the destruction of our beaches and sent the wrong set of signals to an unsuspecting community. The only persons who have benefited from this have been the suppliers of the commodity who have seen the price rise with the apparent scarcity of the resource.

Sand is available in abundance in our various coastal valleys. If the mining of this resource is approached properly it could continue to be an economical source of building aggregate long into the future. We could achieve this without destroying the aesthetics or recreational qualities of our beaches, but if the ad hoc, indirect approach continues, coastal erosion, scars, unsightliness and economic loss by adjacent land owners will be evident. My final words are those of Neal & Pilkey, 1992 **"Don't mine beaches"**

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SAND MINING IN PUERTO RICO: AN OVERVIEW

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ABSTRACT

Due to economic and industrial policies, there was a surge in the development of concrete based construction in the 1960's and 1970's. Peak exploitation from beaches, dunes and rivers in the coastal zone of Puerto Rico occurred during this time. Mining processes, site restoration practices and the environmental impact of the mining are discussed. Alternative sources, which include manufactured sand, weathered granitic deposits and offshore sand deposits, are outlined. Extraction of the submarine deposits is likely to be the next step, although several environmental factors have yet to be addressed.

BACKGROUND HISTORY

The economic and industrial policies implemented in Puerto Rico between the late 1940's and the early 1950's generated a construction boom that increased demand for aggregate production. During the following two decades the surge in the development of a concrete based construction industry tapped sand sources that were accessible and easily mined. Peak exploitation of sand deposits from beaches, dunes and rivers occurred during the early-middle 1970's. The coastal zone of Puerto Rico, defined to extend 1 km inland (PR CMP, 1978), succumbed first to the developers need for sand for several reasons (Handler and Salles, 1988):

Accessibility: Topographically low and level terrain facilitates road preparation and transportation. Low population density allows a certain flexibility in site choices.

Availability: Deposits occur in known accretional environments with economically attractive storage capacities and resource renewal potential.

Minimum Equipment Requirements: Loose, uncemented deposits (in most cases) facilitate removal, preparation and dispatching (often without a sifting or storage phase).

Cleanliness: Typically, coastal sand requires only simple sifting techniques for sorting, ranging from a wide fixed mesh to vibrating belt equipment. Water is not employed and there is no need for establishing sedimentation ponds.

Market: High sand quality (varied grain sizes, low calcium carbonate and humus content) makes it attractive for a wide range of uses that include: the preparation of cement mix, cement blocks and pipes, road asphalt and plastering sand.

EARLY SAND EXTRACTION: NORTH COAST

Figure 1 identifies the three sites on the north coast that were progressively most heavily mined. Before mining, the sites represented a range of different dune types (Nichols, *et al.*, 1987):

Carolina - a single dune ridge paralleling the beach
Hatillo - low massive dunes less than 10 m high
Isabela - high massive dunes greater than 10 m high transgressing landward.

Volumetric measurements of dune size along the entire north coast between 1950 and 1980 reveal that of the calculated volume of 27 million cubic meters of available sand, 16 million cubic meters of sand were removed by mining (Castillo and Cruz, 1980 in Nichols, *et al.*, 1987).

OTHER SAND SOURCES

As the market for sand sources grew and as the easily mined deposits were exhausted, new sites had to be identified. The following table lists the sources from which sand has been obtained in different proportions through the years, including the potential offshore deposits that have been identified but not yet mined.

Where Do We Obtain Sand	Environment	Source
Beach intertidal zone), dune, backdune/inland area	Coastal zone	Transported
River mouths, river floodplains, point bars	River/estuarine	Transported
Offshore deposit	Open ocean	Transported
Inland blanket sands (silica)	Riverine/eastern interior	Residual
Highly weathered granitic rocks	Central/eastern/southeastern mountainous interior	Residual
Manufactured sand (limestone), (gravel, structural wastes, granites)	Northern Karst belt	Manufactured
Lagoons, reservoirs, harbours	Varied	Maintenance dredging
Import (very rare)	Other Caribbean Islands, silica from Florida, Jamaica, Guadeloupe	

Figure 1 Early Sand Extraction: North Coast
(Nichols, *et al.*, 1987)

CAROLINA:

1950's - enormous quantities of dune sand were mined to construct the San Juan Airport,

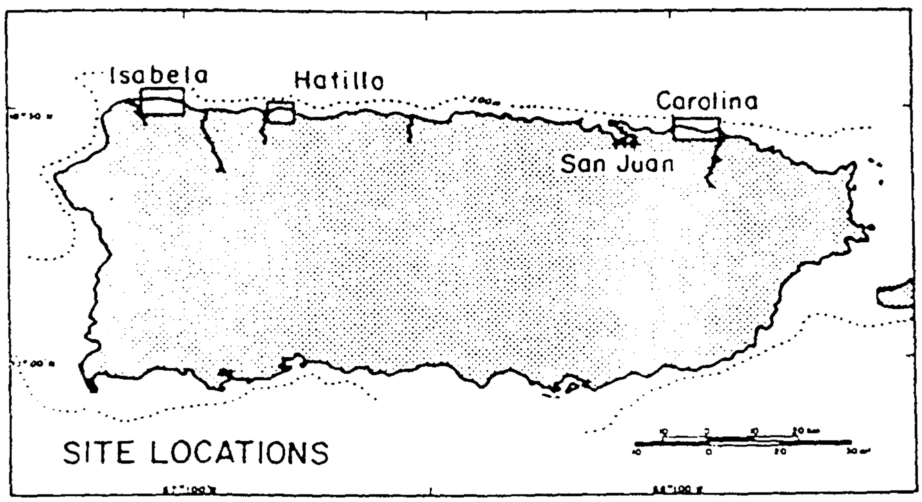
1960's - storm waves breached the remnant dune which was totally destroyed; mangrove flooded; 150,000 cu. m. of sand spread 50 m inland,
later - metal scraps/rocky breakwater,
1986 - dune build-up with river mouth sand, cost: $250,000,
1987 - total washover of dune, restoration lost.

HATILLO:

1960's to early 1970's - intensive mining, broke the integrity of the dune ridge system, inland mangroves buried by washover sand, extraction holes flooded.

ISABELA:

1970's - removal of over 8 million cubic meters of sand from high, massive dune system
1980's - subsequent overtopping and destruction of remnant dunes
1980's to 1990's - active, intensive mining, some effective restorations.



MINING PROCESS

Techniques for coastal zone and floodplain sand mining can range from simple hand shoveling to complex set-ups involving various types of heavy equipment. In general, the operations consist of three basic stages adjusted to site locations:

Land preparation: Clearing of the vegetation using a bulldozer or front-end loader and saving the top soil for later spreading.

Mining per se: Begins with surface raking (usually done with a front-end loader) to remove material in a relatively uniform manner over the work area up to a maximum depth of 1 m above the ground water table or mean sea level, whichever is shallower. The operation may evolve to a dry pit excavation (requiring the use of a bulldozer) or a wet-pit (needing to employ a dragline). Maximum allowed wet-pit depth is 4 m below the water table.

During this mining phase two simultaneous substages take place:

Processing - screening and separation of oversize or trash with a portable screening plant,
Distribution - loading of trucks with loaders (or shovels in the simple hand shoveling operations)

Site restoration: Backfilling with approved material and raising of land levels (where needed) to: (a) pre-extraction land levels, (b) 1 m above the water table/mean sea level, or © an intermediate elevation according to site characteristics. Proper grading for surface and subsurface drainage, topsoil spreading, and planting of the disturbed area with local proven vegetation are also required. Often, restoration procedures stop, temporarily or permanently, at one of these steps.

MINING IMPACT

Sand mining operations are necessary in a growing economy dependent on urban, commercial and manufacturing developments. But, there is an environmental price. Sand mining does have the following impacts:

* partly modifies or completely changes the local topography and drainage patterns,

* significantly disturbs or permanently alters the ecological systems present prior to mining,

* increases surface susceptibility to erosion,

* increases sedimentation of low lands,

* increases susceptibility to flooding and temporary or permanent ponding,

* increases susceptibility to the overall impact of storm events and other natural hazards.

The degree of these impacts will vary depending on the site's topography, lithological/soil characteristics, precipitation patterns, surface/subsurface drainage capacities, degree and type of vegetation cover, and extent of urbanization and development.

Although environmental perturbation is inherent to the mining process, these operations can be done with reduced environmental impact if:

* site conditions prior to mining are evaluated to design adequate mining methods and rhythm; and if

* restoration practices are properly implemented and followed through.

SAND MINING STATUS

Since 1968-69 studies and assessments have stated that the construction industry in Puerto Rico will face a shortage of sand in the near future (Christiansen, *et al.*, 1969; Management Aid Center, Inc., 1969). The future has arrived and the increase in sand consumption has accelerated depletion of accessible sources in known accretional environments.

Restrictions in tune with land-use compatibility and conservation/ preservation of the island's natural resources have been emplaced in the past and will need to be enforced in the near future. This limits the use of many deposits, some of which are at present recovering from past impact, such as the rebuilding of some stretches of the north coast duneline.

With the purpose of minimizing extraction impact on beaches and rivers the following have been identified as the major alternative sources of sand:

Manufactured sand: Produced principally from the northern limestone belt, its major environmental drawback is that it causes the destruction of the karst morphology. Accessible deposits are also found on the south coast. Production costs are higher but its use requires less cement, offers superior bonding and smoother termination than natural sands (though, for safety reasons, manufactured sand must be mixed with river sand in road construction) (Cintrón, *et al.*, 1984).

Medium to highly weathered granitic deposits: Exploitation and expansion of mining operations have been controlled by the accessibility and limited extent of the deposits.

Submarine sand and gravel deposits: Twenty three potential deposits have been identified, three of which represent feasible commercial sites due to the volume and quality of the available material, and probable physical impact of extraction on nearby bottoms, shorelines, water column, biological impacts and loss of marine productivity. These sites are offshore: Isabela (north coast), Cabo Rojo (southwest coast) and Vieques Island to the east. Relevant information of these sites are summarized in Figure 2. At present, the Cabo Rojo West submarine deposit has been assessed as the best alternative because it represents less environmental risk.

CONCLUSION

Extraction of the submarine deposits is likely to be the next step in the sand mining history of Puerto Rico. This is a controversial and complex issue. There has been a tendency to delay the decision to further study the viability of this alternative due to economic and environmental reasons (Cintrón, *et al.*, 1984; Forrest, *et al.*, 1995):

Economically, the following factors have to be considered:

* high extraction/transportation costs,
* need of sophisticated equipment,
* accessible harbor,
* adequate ports facility for storage/distribution.

In terms of the environment, three major concerns have to be addressed before any extraction is done:

1. Will the depression created by the extraction act as a sink intercepting sand that would otherwise replenish nearby beaches?

2. Will the depression result in greater wave activity affecting nearby beaches?

3. Will the depression cause the sand from the nearby beaches to move towards the sink, resulting in beach erosion?

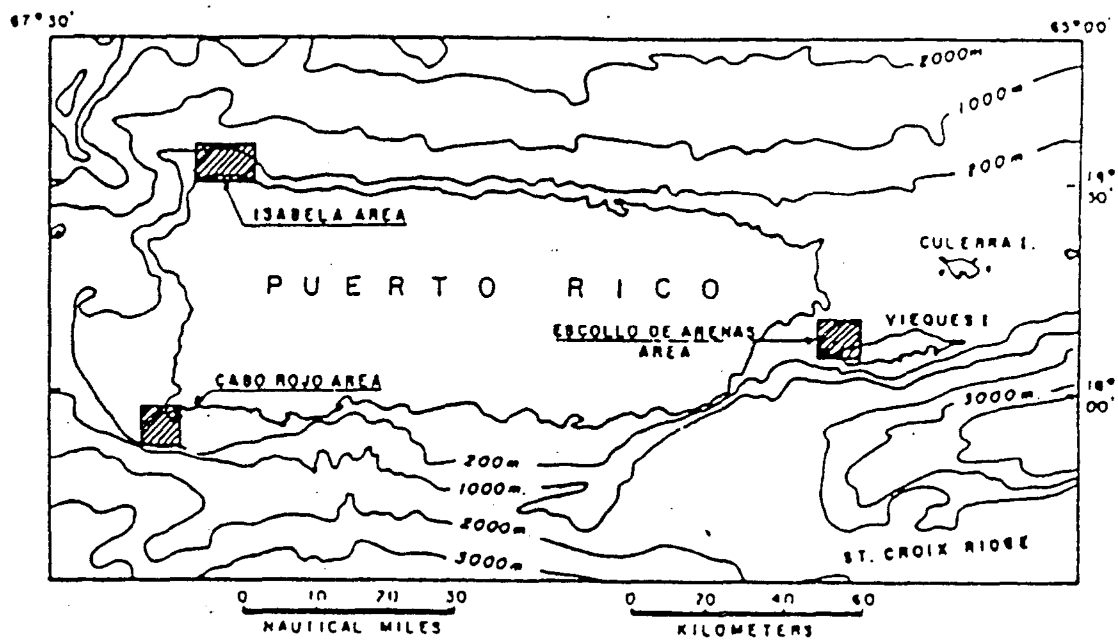
Also, the direct consequences to the nearby coral reefs and sea grass beds have to be further analyzed.

The ultimate environmental implications of submarine sand extraction are unknown. Historically, the short term economic gains associated with sand mining operations have generally overshadowed both short and long term environmental impacts.

Figure 2 Location of Offshore Sand Deposits
(Cintrón, *et al.*, 1984)

ISABELA:

- thin sand pockets at 30 - 45 m depth
- low volume of sand (8 million cubic meters, uncertain)
- rough sea conditions (Atlantic Ocean)
- recovery economically unfeasible for present technology
- unlikely adverse physical or biological impacts



CABO ROJO WEST:

- shoal 33 km sq - 2 to 6 m thick
- 80 million cubic meters
- water depth 10-15 meters
- recommended for immediate exploitation
- impact on fishing industry, adjacent sea grass, coral reefs, tourism.

ESCOLLO DE ARENAS

- large linear sand and gravel deposit with beachrock
- 6 km long, 50 - 1200 m wide 7 m thick water depth: 4-8 m
- Economic potential: 30 to 90 million cubic meters
- Impact: increased wave energy, substantial destruction of productive (nursery) seagrass beds

Therefore, the approach to this issue requires caution and the implementation of management practices that integrate a sound evaluation of product demand, site selection and mining practices with resource replenishment limitations and potential environmental disturbances. Short-term economic gain strategies must be analysed against long-term environmental protection policies to maintain the impact on the natural resources to a minimum.

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BEACH SAND MINING IN ST VINCENT AND THE GRENADINES AFTER THE LANDMARK DECISION OF 1994

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ABSTRACT

Traditionally, beaches and the Rabacca Dry River have provided the principal source of construction sand in St Vincent and the Grenadines. This has resulted in severe beach erosion, flooding of coastal areas, loss of dunes and other habitats. Following a regional study, it was decided to import sand into St Vincent from Guyana for use in the construction industry. This would result in increased construction costs, since beach sand had been considered a 'free good'. A decision was announced in December 1994 that imported sand would be used for all Government construction projects starting 1st January, 1995, and that controls would be instituted on beach sand mining, although no date was set for this action. This announcement resulted in a massive stockpiling of sand, in a two month period the volume of sand mined from the beaches was 2.5 times the annual volume. This caused serious erosion which was accentuated by Tropical Storm Iris in August, 1995. It is concluded that the populace may not be prepared to pay the price of imported sand and that short term gain outweighs long term national benefit.

INTRODUCTION

This paper is intended to provide some information on the nature and extent of the problems related to sand mining in St. Vincent and the Grenadines, and to discuss the problems that arose when the Government made the landmark decision to reduce the level of sand mining in 1994. It is hoped that the lessons learnt from the St. Vincent and the Grenadines experience will assist other OECS states who may be contemplating the imposition of measures to reduce sand mining. The paper begins with a general background on St. Vincent and the Grenadines, then looks at the importance of coastal resources to the national development process, then deals with Government proposals to reduce the level of sand mining and its impacts.

OVERVIEW OF ST VINCENT AND THE GRENADINES

St Vincent and the Grenadines is an archipelagic state comprising over thirty islands, islets and cays, located between St. Lucia and Grenada and to the west of Barbados. St Vincent is the main island with most of the population and major settlements including the capital city Kingstown. The smaller islands in the chain are called the St Vincent Grenadines and comprise the major inhabited islands of Bequia, Mustique, Canouan, Union Island, Palm Island and Petit

St Vincent.

Table 1 Characteristics of the Islands of St. Vincent and the Grenadines

Island	Area (sq. miles)	Population 1991
St. Vincent	133	98,842
Bequia	7	4,867
Mustique	2	4,874
Canouan	3	739
Mayreau	1	182
Union and Palm Island	4	1,928
Total		111,433

St Vincent, which is usually referred to as the "Mainland" is volcanic in origin and is dominated by a central mountain range which is covered in wet forests and a series of radiating spurs which reach down to the coastline. The island is drained by numerous rivers and has many black sandy beaches. The island has an active volcano - La Soufriere - over 4,000 ft. high which last erupted in 1979.

St. Vincent has very fertile soil and agriculture is the major economic activity. Agricultural activity is concentrated on the lands under 2,000 ft above sea level - usually in the river valleys and the steep hillsides where there is intensive farming. Banana is the main cash crop and accounts for over 75% of the total agricultural exports in recent years. Most of the land above 2,000 ft above sea level is undeveloped and is forested and critical for the protection of water catchment and biodiversity.

Presently there is limited tourist activity on St Vincent despite the great potentials for nature tourism. Most of the tourism activity is located in the south near the few white sand beaches. Most of the human settlement activity is also located in the south with 60% of the population living in a 5 mile radius from Kingstown. Most settlements are located on the coast with few settlements being more than 4 miles from the coastline.

The Grenadines, on the other hand, are very small islands, with a series of dry hills, white sandy beaches, clear blue waters and sheltered and extensive coral reef systems. There is limited agricultural activity on these islands since they receive very limited rainfall (40 - 50 inches annually). Most of the agricultural activity is subsistence in nature. Tourism is the major economic activity in the Grenadines as these islands have great tourism potential. There is emphasis on up-market tourism on some of the islands - Mustique, Petit St Vincent and Palm Island are developed as private resorts catering for international 'rich and famous stars'. The Grenadines are renowned for sailing, snorkeling and other marine recreational activities which attract significant numbers of visitors. Traditionally, the local people, who live in very small villages, make a living from the sea - fishing, boat building and by sailing on regional and international shipping lines.

ECONOMIC BACKGROUND

The economy of St Vincent and the Grenadines in terms of Real Gross Domestic Product (GDP) has grown by a remarkable average of 7% annually over the past decade. The main sectors of the economy are agriculture (18%), transport and communications (22%) and government services (14%).

Agriculture remains the key sector of the economy. In 1992 it accounted for 80% of merchandise export earnings and 60% of direct and indirect employment, (unemployment is estimated to be about 19%). Banana is the chief crop. Government's policy in the transport and communications sector is to improve and maintain the country's infrastructure to facilitate economic growth.

In addition to agriculture and education, tourism has top priority with respect to the development of the country. Government is particularly interested in up-market tourism focusing on eco-tourism.

Manufacturing accounts for 9% of GDP. Government's manufacturing sector strategy is to attract entrepreneurs, both foreign and local, to maximise employment and facilitate skill development.

Overall Development Strategy of the Government of St Vincent and the Grenadines

The Government's overall development strategy is to promote balanced growth and to ensure that the development is sustainable.

The Government's strategy for sustained development is aimed at increasing output and improving productivity. The Government recognizes the central importance of the private sector in achieving these growth objectives and views its objectives as those which create the conditions in which growth can take place.

In agriculture, the main policy thrust is to diversify away from bananas which are facing stiff competition on the European market. In manufacturing and tourism, the thrust is to promote private sector investment through fiscal incentives and provision of infrastructure. For all sectors, human resource development is seen as fundamental for sustained growth.

THE IMPORTANCE OF COASTAL RESOURCES IN THE DEVELOPMENT OF ST VINCENT AND THE GRENADINES

St Vincent and the Grenadines, like all small island developing states in the Caribbean, has limited resources, but fortunately possesses a relatively productive and exploitable coastal and marine area. The small size of St. Vincent and the Grenadines, and indeed all of the OECS states, makes it very difficult to distinguish coastal from non-coastal areas and the whole island is considered the coastal zone/area.

The coastal and marine ecosystems of the islands of St. Vincent and the Grenadines are of considerable value to the national economy and to the quality of life. Most of the central forest areas of these islands must be protected to ensure a reliable quality and quantity of water and to preserve biodiversity. Since European settlement began in the 1660's the littoral area has been the primary focus for development. Today, the coastal areas are the areas of greatest economic and human activity - agriculture, fishing, industrial development, tourism, human settlements, housing, social and physical infrastructure etc.

The multiplicity and intensity of land uses in the "coastal areas" of St. Vincent and the Grenadines is generated by development pressure from an expanding population and the particular style of development adopted by the population. The increase in development pressure is placing greater stress on the interacting terrestrial and marine ecosystems, and the multiple uses of the coastal resources is resulting in serious land use competition and land use conflicts which threaten the potential for sustainable development. In order to ensure that the fragile and limited natural resources of these islands are conserved and developed in a sustainable manner, there is need for implementable and relevant natural resource management systems and practices. The Government of St. Vincent and the Grenadines, like most governments in the Caribbean, is now realising that there is need to protect terrestrial and marine resources for sustainable development. However, the Government lacks the technical, financial and human resources to develop the appropriate natural resources management systems.

As a result, coastal and marine resources are undergoing extensive degradation resulting from many unsound environmental practices including:

- poor coastal engineering.
- sand mining on beaches,
- removal/degradation of natural protective structures such as reefs,
- land reclamation and destruction of coastal wetlands,
- dumping of garbage,

- industrial and municipal effluent,
- agricultural runoff,
- excessive fishing,
- destruction of habitats for construction and other development activity,
- bad siting of development activity.

THE PROBLEM

The principal sources of sand for construction have been the beaches of St Vincent and the Grenadines and the Rabacca Dry River. The demand for sand for building and construction purposes has been increasing rapidly over the years. In St Vincent and the Grenadines, sand consumption figures are not recorded or easily available. Consumption levels for sand were estimated (Atkins, 1993) as a function of the demand for cement. Table 2 shows the estimated consumption of sand for the years 1982, 1986 and 1990.

Table 2 Estimated Consumption of Sand 1982-1990 in St Vincent

Year	Cement	Sand (tonnes)
1982	15,240	38,000
1986	22,673	56,000
1990	39,036	96,000

According to Atkins (1993), 62% of the sand consumed was obtained from the Rabacca River. This sand is of variable quality, coarse grained and contains gravel sized pebbles. This type of sand is suitable only for concrete and pre-cast structures. Another 30% of the sand consumed was obtained from the Brighton/Diamond dune system and other beaches in St Vincent and the Grenadines. This beach sand is fine grained and is used in plastering and rendering work. 8% of the sand consumed was derived from crushed rocks.

The removal of sand from the beaches is creating serious problems, including:

1. loss of scenic value;
2. destruction of dunes with their interesting and rare biological habitats;
3. destruction of turtle nesting areas;
4. loss of beach land which is a major recreational attraction;
5. blighting of mined beaches by illegal dumping;
6. flooding of coastal lowland area;
7. increased coastal erosion and destruction of coastal properties (land and buildings).

If beach sand mining is allowed to continue at its present pace, and in such an unsustainable manner, the potential for the development of the tourism and fisheries sectors would be greatly reduced and the country would be unable to supply and ensure adequate income, employment and essential social services to all its citizens.

In addition, beach sand is contaminated with salt which leads to the spalling of concrete and corrosion of steel reinforcing bars, which reduces the structural integrity and lifespan of concrete structures.

The Government considered it necessary to cease beach sand mining and to develop alternative supplies. Within the country there is no viable source of sand and the Government decided to pursue the option of sand importation.

Recognizing the commonality of the sand mining problems among OECS Member States and the advantages of bulk purchasing and bulk transportation of imported sand, the Government spearheaded efforts at the OECS level for jointly exploring the possibilities of importing sand from Guyana for all the OECS States.

The OECS Secretariat secured funding from the European Union and the consultancy firm of W.S.Atkins Ltd, was commissioned to undertake the OECS-Guyana Sand Supply Study on behalf of the OECS States and Guyana. The final report of the study was submitted to the OECS Governments in February 1993. The major findings and recommendations of the study were:

1. Beach sand mining in OECS States results in grave environmental damage and the high salt content of the sand produces poor quality concrete structures.

2. OECS States need to import sand for construction purposes and the white sand deposits along the Demerara River in Guyana would be the best place to secure high quality sand.

3. It is essential to establish a Caribbean Sand Mining Company (CSMC), a private enterprise organization with a substantial minority share holding taken up by the OECS Member States which could be responsible for:

(a) sand mining operation in Guyana;
(b) transportation of sand from Guyana to the OECS States in 10,000 tonne barges.

4. Within each Member States of the OECS, a sand importation facility should be developed by a private sector company to off load, stockpile and distribute sand for national consumption.

5. The importation of sand from Guyana is financially possible and environmentally sound, but needs the commitment of all OECS States to develop and efficiently enforce a ban on beach sand mining.

6. The imported sand will be more costly than beach sand in most states, and transportation costs will make sand in the northern OECS States more expensive that sand in the southern OECS.

7. The imported sand will be of a higher quality and give more value per dollar than local beach sand.

8. Importation of sand will conserve critical fisheries and tourism resources and so ensure sustainable development in the OECS.

Sub-regional activity and reaction to the OECS/Guyana Sand Supply Report have been very slow. To date there has been little sub-regional response. It is believed that some states are not willing to pursue the importation of sand since the increased cost of sand may lead to serious political implications for the ruling party. The Government of St Vincent and the Grenadines, like the Government of St Lucia, recognized that joint action by OECS Member States was not forthcoming and so decided to develop a national initiative. The Government's position was clearly articulated by the Prime Minister, who stated that the problems of sand mining are too grave to sit and wait on other OECS States and that the Government is intent on proceeding with the importation of sand and to 'go it alone' if necessary.

THE GOVERNMENT'S INITIATIVE

There was great private sector interest in St Vincent and Guyana in the development of the sand importation trade. A Guyana mining company offered to supply sand at US$ 14 CIF or EC$ 10 per tonne. In addition, a group of Vincentians formed a company "The Sand Piper Company", and acquired a barge and was willing to supply sand from the cheapest external source to meet national demands. The Sand Piper Company offered to supply sand at EC$ 40 - 45 CIF per tonne.

The Government, after a series of in-depth studies and analyses, decided that it was going to facilitate a sand importation programme under the following arrangements:

1. Government will develop a sand landing and storage facility at Lowmans Bay for use by private operators. This site will be leased to a private operator through a tendering process. The lessee will operate at his commercial risk.

2. The Government will recoup the expenditure for the development of the jetty, ramps etc. at the sand leasing facility through lease/rental payments from the lessee.

3. The lessee will not be given a monopoly to import sand and he will not be entitled to exclusive rights to use the site. Other persons will be permitted to import sand and a specified rate of payment will be charged by the lessee for use of the facility.

4. The purchasers of sand have the right to determine the trucking arrangements for the sand. The lessee may provide trucking services to purchasers only at the purchasers' request.

5. No Government projects will use beach sand and the Government will purchase imported sand through the sand importation facility.

6. Persons or firms receiving concessions from the Government for construction and development projects will be required to use imported sand.

7. Government will embark on a geographically phased programme of reduced sand mining, key elements of this programme are:

(a) Persons in the south of the island defined as south of the Colonarie and Cumberland Rivers will be required to use imported sand since sand mining will be prohibited in the south. Persons in the Grenadines had to use imported sand as beach sand mining was prohibited on all beaches.

(b) Persons in the north of the island will be permitted to use beach sand. However, sand mining will be controlled and managed. Sand in the north of the island will now be sold at the same price as the imported sand at the landing site.

(c) Sand mining at the Rabacca River will be controlled and fees similar or a little below the cost of imported sand imposed.

8. The development of strong enforcement mechanisms to ensure sand mining is carried out in keeping with the stated policy.

Implications of the Government's Proposal

The proposal by the Government for the importation of sand and reducing the level of sand mining will impact on the price of sand and the cost of construction in St Vincent and the Grenadines.

Historically beach sand has been a 'free good' and nationals went to the nearest beach and took unlimited amounts at no cost. There is still the perception in some quarters that it is God's sand which is provided in unlimited supply.

Presently beach sand is virtually free as the consumer will pay only the trucking cost from source to the point of consumption. The cost therefore varies from place to place and is a function of the transport cost from source to consumption point. Table 3 shows the cost of sand mined from Brighton, the major sand mining site on St Vincent.

Table 3 Cost of Sand from Brighton/Diamond in 1994

Place	Cost EC$ per Truck Load
Kingtown	110
Arnos Vale	100
Prospect	80
Mesopotamia	130
Layou	160
Barrouallie	250
Chateaubelair	300
Georgetown	200

The table shows that persons closest to Diamond will pay lower costs and persons furthest away will pay the highest costs. In practice, however, persons who are distant from the Brighton/Diamond area avoid using sand from the Brighton/Diamond area given the high transport cost, and mine sand from the nearest beach.

If imported sand is landed at Lowmans Bay at ES$ 40 per tonne, and a truckload of sand is the equivalent of 6 tonnes with a 30% increase provision for profit, handling and other operational costs, a truck load of sand will cost approximately $300 at the landing site. When transport costs are included, an interesting cost comparison between local and imported sand emerges as is shown in Table 4.

Table 4 shows clearly the use of imported sand will increase the cost of construction which will impact primarily on the housing sector and create greater difficulties on the efforts of low income groups to house themselves. In addition, the cost of public sector infrastructure projects, especially roads and other unit works (where sand and aggregate account for 30% of the total cost), will increase by a greater margin.

The overall effect of imported sand and reduced sand mining could increase unemployment, and lead to a slowdown in the economy in which the construction sector is the second biggest contributor to the GDP. The Government, in its proposal, adopted a phased approach, which would try to reduce total cost of sand by trying to minimise the transport distance of sand from source to consumption point. Using this approach, the cost of sand would not have exceeded EC$ 450 per truck load at any point in St Vincent.

Table 4 Comparative Cost of Local vs. Imported Sand at Various Locations in St Vincent and Potential Impact on Construction Costs.

Place	Cost of Sand from Diamond	Cost of Imported Sand at Lowmans	Transport Cost from Lowmans	Total Cost of Imported Sand	$ Difference in Cost, Local vs Imported	% Increase in Construct-ion Costs
Kingstown	110	300	80	380	245	2.5
Arnos Vale	100	300	100	400	300	3.0
Prospect	80	300	130	430	437	4.5
Mesopot-amia	120	300	160	460	283	2.6
Layou	160	300	100	400	150	1.5
Barrouallie	220	300	130	430	95	1.0
Chateau-belair	300	300	220	520	73	0.7
Georgetown	200	300	200	500	150	1.5

With respect to the Grenadines, the proposal had varying impact on the price of sand and the cost of construction. Over the last eight years, there has been limited sand mining on the islands of Bequia and Mustique. These islands imported sand from St Vincent at approximately $800 per truck load. Importation of sand directly to Bequia by barge was possible and results in a near 60% decrease in the cost of sand as a truck load of sand at consumption point would have been priced at a maximum of $ 400 ($300 at landing site, $100 maximum for trucking coast). Mustique is expected to receive lower sand costs as Bequia for similar reasons.

However, Union Island, Canouan and Mayreau have a very small sand demand and it has been uneconomical and very difficult to entice suppliers for these small markets. The residents of these islands are therefore placed in a situation in which there is a ban on sand mining and no viable alternative provided. It was hoped that the developers of major tourism projects who were importing sand will provide sand for purchase by local residents.

The Announcement of the Decision to Ban Sand Mining

The Government declared the 1990's as "The Decade of the Environment" and the issue of alternate means of provision of sand for construction was in debate since 1990. During the preparation of the National Environment Action Plan (NEAP), the issue was hotly debated. At the national consultation of the NEAP which was attended by over 150 persons from near 80 organizations, it was decided that sand mining should be discontinued and that arrangements should be made for sand importation. The Vincentian public therefore had some knowledge of the expected action.

In August 1994, the Government passed regulations under the Town and Country Planning Act which attempted to control the use of beaches and restricting certain activities on beaches without permits. These activities included sale of goods, noise, mining of sand and coral etc.

In early December 1994, at the opening of a regional Coastal Zone Management Workshop sponsored by the United Nations Development Programme, the United Nations Centre for Human Settlements, and the OECS Natural Resources Management Unit, the Director of Planning announced to a largely foreign audience that it was the intention of Government to institute controls on sand mining in 1995. The Director of Planning's speech was later aired on radio and television.

The Hon. Prime Minister and Minister of Planning in presenting his budget address for the 1995 fiscal year in mid December 1994, informed the nation that with effect from 1st January 1995, the Government would not be using beach sand for Government construction projects and would instead be using imported sand for all construction projects.

A great deal of the budget debate was centred on the sand mining issue with the opposition laying claims that there was a covert plan to ban sand mining on all beaches from 1st January, 1995, and that the impacts would be grave on all low income persons and the economy as a whole. The opposition pointed to the planning regulations on beaches and the announcement by the Director of Planning to support its claim. In addition, they quoted figures of a truck load of sand to cost over $1,000.

The Prime Minister in winding up the budget debate, presented the Government's thinking on the matter as highlighted above and stated clearly that no implementation date was set for this programme, but that Government wanted to lead by example and so Government would use imported sand on all its projects from 1st January, 1995.

The Aftermath

The issue of sand mining became most topical from December 15th, 1994 among the populace. The people were confronted with much conflicting information on the price of imported sand, implementation dates etc. There was little that the Government could do to explain their contention.

Panic stepped in and there was a mad rush to stockpile sand among the truckers, contractors and would-be house builders. From the period 18th December, 1994 to the end of January, 1995, there was non-stop sand mining and stockpiling of sand on private properties as well as on roadsides. Heavy equipment operators worked 18-22 hours on Christmas Day and all public holidays during that period. Sand mining took place on all beaches. The volume of sand mining undertaken during that period at the main sites, (Brighton/Diamond) is estimated to be over 2.5 times the volume extracted on an annual basis. It has been reported that even some Government agencies were involved in the sand rush and were directed to return the sand stockpile after 1st January, 1995 to the beaches.

From 1st January, 1995, the Government commenced the use of imported sand on Government projects and Cabinet appointed a Committee, which consisted of Government Ministers and senior civil servants, to advise on the problems of sand mining. To date, no follow-up action has been taken on the implementation of the Government's proposed plan.

The stockpiling of sand created major problems in the early months of 1995. Most of the sand that was stockpiled on private properties was never utilized in construction. The sand created serious problems:

- It was left to be blown away and create a serious nuisance in residential communities;
- It created major traffic hazards, especially for cyclists, as it was left on the surface of most roads;
- It clogged drains and gullies and led to serious disruption of the drainage systems.

During the first six months of 1995, there was extensive non government organization (NGO) consultation and discussions on the issue with the public generally denouncing the "sand rush of December 1994", and recommending that Government pursue the importation proposal at minimum cost to consumers. The Government, however, appeared quite silent on the issue and awaited a report of a survey on the beaches which was undertaken by senior civil servants.

In August 1995, St Vincent and the Grenadines suffered the effects of Tropical Storm Iris. Most of the beaches were severely damaged and there was significant damage to coastal properties. In addition there was extensive flooding at the Brighton/Diamond sand mining site. The back shore area of this major mining site is now permanently under flood waters. The issue of sand mining is again a major talking point, with criticism being leveled at the Government for not being forceful and resolute in its plan to ban beach sand mining and facilitating the importation of sand for the entire country.

The major lessons learnt from the St Vincent and the Grenadines attempt at instituting alternatives to sand mining are:

1. The issue of environmental management is critical to sustainable development of island states and must be addressed from a long term perspective rather than the ad hoc and short term basis

as presently obtains. Costs and benefits of development activities must therefore incorporate the long term dimension.

2. It is relatively easy to identify the major environmental issues facing small island states and to propose technical solutions to these problems. However, implementation of these proposals is very difficult as there are many social, political and economic implications which must be addressed in detailed.

3. The process of consultation and consensus building may be critical to the process of developing alternatives to sand mining, but in the final analysis, stakeholders may defend their selfish interests rather than the broader national interest.

4. Political will of the Government and opposition is critical in the implementation of alternatives to sand mining. It is very difficult to get political consensus on this issue. The Government must ensure that the opposition parties are interested and committed to sustainable development as it relates to the sand mining issue. If there is not consensus and opposition support, the effort may be futile as the opposition parties may oppose the proposed strategy simply for political mileage. Maturity of political parties and their ability to support issues from a national viewpoint, rather than from a narrow political partisan perspective, is therefore critical.

5. The social benefits of developing alternatives to sand mining may be great, but at the end of the day, the private costs or disadvantages as expressed in monetary terms will determine if beach sand mining will continue.

6. Strong resistance and/or failure on the part of Government to institutionalize a ban on sand mining makes it very difficult and almost impossible for the Government to make a second attempt at restricting sand mining.

7. Public information flow on contentious issues like restrictions on sand mining must be clear and well organized. Government agencies must develop an effective public awareness programme with designated personnel to inform the public in a coherent manner on the policy. Different messages from different public officers leads to distrust and scepticism on the part of the public.

8. The announcement of commencement dates in advance of a sand mining restriction policy may be very detrimental; since it may lead to excessive sand mining and stockpiling of sand.

9. There is need for an effective and efficient enforcement capacity that is fully functional and operational prior to establishing and announcing policies related to a cessation of sand mining.

CONCLUSION

Sand mining remains a major problem for St Vincent and the Grenadines, and most of the OECS Member States. Attempts at developing alternatives to beach sand for construction have been hindered largely by the prevailing perception that sand is a 'free good' and by short term cost considerations. Government's success in the importation of sand as an alternative to beach sand mining has been confined to public and private sector projects which received concessions from Government and to all construction activity on the islands of Bequia and Mustique. The present level of sand importation will reduce the level of beach destruction but will not significantly reduce the level of uncontrolled sand mining and beach destruction at the major mining areas. The populace may not be prepared to pay the price of imported sand, but increasingly state funds are being budgeted and utilized to pay for remedial works. These include sea defenses, coastal rehabilitation, beach renourishment programmes and protection of threatened roadways, all as a result of sand mining and man's action in the shoreline area.

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SEEKING SAND SOURCE ALTERNATIVES: AN ISLAND CASE STUDY

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ABSTRACT

At present rates of demand, onshore sand reserves in Anguilla will be depleted within one to two years. The present reserves are provided from the only licensed quarry mining operation. Evaluation of the alternatives provides the following options for Government planners:

1. *Back to the beaches: this alternative is not acceptable to Government, who are attempting to prevent further damage to beaches, dunes and coastal environments, given their critical importance in national economic development.*

2. *Sand imports: to satisfy island sand demand of about 20,000 cubic meters per year, this option will require a substantial increase in sand imports over those previously brought to the island. There are a range of sources for this material, all of which would need to be shipped in.*

3. *Offshore sand: geophysical and geological investigations identified three large pockets of sand on the shelf close to the north coast. Each pocket contains several million cubic meters of sand, more than enough to satisfy demand for the foreseeable future.*

It is technically feasible to mine the offshore sand. Assessment of this operation from an engineering, environmental and cost/benefit perspective suggests that one of these deposits, located off the northwest coast, has a good overall profile as a sand source, and potential impacts associated with extraction can be mitigated. This sand could be slurried to the site of the existing active quarry for washing and stockpiling. Both the imported and shelf sand sources require resolution of potential land use conflicts in the context of the Draft National Land Use Plan. However, for a twenty year sand supply, shelf sand could be mined and stockpiled at approximately 50% of the cost of imported sand, with a net saving of foreign exchange, allowing for the costs associated with mitigation measures and washing to remove salt.

(This paper will shortly be published by a peer reviewed journal).

COMPARATIVE MANAGEMENT OF BEACH SYSTEMS OF FLORIDA AND THE ANTILLES: APPLICATIONS USING ECOLOGICAL ASSESSMENT AND DECISION SUPPORT PROCEDURES

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ABSTRACT

A primary contrast in beach system management between Florida and the Antilles involves the differential utilization of sediments. Although sediments are mined in both regions, the sites and destinations differ substantially. In Florida, sediments are dredged from submerged deposits and dumped on beaches and subtidal habitats, while in the Antilles they are primarily mined from beaches and used as construction material. Within both regions, there are needs to optimize multiple policy issues raised by these approaches. Recent methodological developments within the fields of environmental assessment and decision-support may aid evaluations of these and related issues. Using comparative ecological risk assessment and analytic hierarchy procedures, preliminary frameworks to identify optimal policy combinations were developed for: beach nourishment alternatives in Florida, and construction material alternatives in the Antilles. Preliminary results from both examples are presented, with emphasis on the assessment of environmental effects of differing nourishment alternatives upon coastal fish populations of southeast Florida. The frameworks produced logical and explicit characterizations of highly complex problems, but do not yet represent definitive results. Both frameworks were designed to foster future revisions by local experts for further application within both regions. Upon systematic application, group-based environmental assessment and decision-support tools can substantially aid the evaluation of diverse coastal management issues throughout the Caribbean region.

INTRODUCTION

Coastal managers face similar information and policy needs in Florida and the Lesser and Greater Antilles. However, specific ecological and socio-economic attributes of these systems can vary widely between regions. Comparative identification of areas of both overlap and divergence can help to sharpen approaches to the management of both regional systems, and potentially, generate transfers of previously isolated technical or administrative experiences which benefit both systems.

Many fundamental needs in both regions revolve around two issues. First, there is a common need for baseline environmental information, collated in a systematic structure, which identifies key voids and allows assessment of the effects of anthropogenic modifications. This derives partially from the importance of environmental impact assessments (EIA's) in both Florida and the Caribbean islands. Having a variety of specific names (e.g., environmental impact statements, biological characterizations, etc.), these reports are often the primary technical and administrative evaluation of the biological effects of large-scale coastal modifications. Such reports are useful but can emphasize limited existing information at the expense of evaluating the significance of what is not yet known. Resulting conclusions can be oriented towards why the project will have acceptable impacts instead of detailed consideration of: 1) what still is not known, and 2) the actual lethal and sublethal effects on the varied populations impacted. In addition, there is a frequent lack of consideration for cumulative impacts (Spaling and Smit, 1993, Dixon and Montz, 1995), despite a large literature demonstrating the profound effects that multiple projects within a region can have (Odum, 1982; Cocklin *et al.* 1992; Rothschild *et al.* 1994; Vestal and Reiser, 1995). Such cumulative effects can develop even when the effects of one project alone (the scale of the typical EIA) are subtle, and therefore administratively acceptable. The probability of some of the nearshore habitats or organisms of southeast Florida or the Antilles being subject to "death by a thousand cuts" scenarios which have affected other natural systems (preceding references) subjected to frequent, "relatively benign" disturbances is infrequently developed as an issue in EIA's.

Second, there is a common need for systematic decision support techniques which offer logically consistent methods to detail and cumulatively evaluate policy decisions. Management of coastal systems involves complicated syntheses of geology, engineering, biology, law, economics, and politics. Administrative decision-making involves the extraction of conclusions from these complex scientific and political arenas despite often competing agendas. Not surprisingly, real-world coastal management decisions are sometimes made in relatively oblique manners, characterized by the absence of formally structured analytical procedures. In the absence of explicitly structured logic paths for decision-making, the appearance of subjectivity is increased, and opportunities for constructive, retrospective analyses are reduced. Explicit use of logical decision-support methods reflects a commitment to open and objective policy-formulation.

Recently, useful methods to deal with both of these issues have been independently developed. First, after substantial developmental work, a revised framework for assessing the environmental effects of human activities (comparative ecological risk assessment, CERA) was formalized by the EPA in 1992. This approach involves simultaneous evaluations of both stressors, effects, and their potential co-occurrence using flexible protocols which help insure comprehensive evaluations of effects (EPA, 1992; Harwell *et al.*, 1995). The applications of CERA principles to EIA's could result in more comprehensive technical products which also carry more administrative weight. Second, decision support procedures, originally developed for industrial and political applications are now frequently applied in natural resource management (Keyes and Palmer, 1993; Schmoldt *et al.*, 1994). These systems aid decision-making among multiple policy alternatives by categorizing system complexity based on group-based weighting of factors at multiple levels of significance. Both of these approaches can be applied in iterative manners and by use of group-based protocols.

Synthetic applications of CERA-based ecological assessments and flexible decision support procedures may substantially enhance the scientific and public policy objectives of coastal management in both Florida and the Caribbean islands. The objectives of the present study were to investigate this possibility within the limited space available by preliminary construction of: 1) a comparative summary of fundamental attributes of beach systems in both regions, 2) a framework for environmental assessment of the effects of differing beach management alternatives in southeast Florida which incorporates applicable decision-support procedures, and 3) an outline of potential ecological assessment and decision support frameworks for beach management alternatives in the Antilles. These ecological assessment and decision-support frameworks can serve as templates for future comprehensive examinations of beach management issues on a region-specific basis.

METHODS

Ecological Assessment Frameworks

For both regions, recently developed protocols based on a broad 3-stage process for CERA development (EPA, 1992; Harwell *et al.*, 1995), provided a useful framework for evaluating the project objectives. Primary subcomponents within each of these three stages are summarized in Figure 1. The CERA process simultaneously evaluates information on both the specific stressors introduced by an anthropogenic event and the biological effects upon the organisms and life stages in question. Subsequently, detailed information on stressors and effects is integrated based on spatial and temporal patterns of co-occurrence using quantitative and qualitative techniques specific to the problem. Due to the inherent complexity of characterizing stressors, effects, and their co-occurrence, full-scale ecological risk assessments are large projects, typically requiring a team of experts. The mechanics of executing a full CERA are detailed in the above references.

The present study provides selected sections from preliminary ecological assessment frameworks based on issues of importance to the environmental management of beach systems within two regions of the Caribbean. For Florida, the environmental effects of ten beach nourishment alternatives upon marine fish populations were evaluated based on details from a larger study (Lindeman, in prep). Most components within this assessment are not included here due to space limitations. However, the information presented here was adequate for the construction of multi-criteria hierarchies for preliminary decision-support analyses.

For the Antilles, the environmental effects of seven alternative sources of sand for construction material (aggregate) were structured in a preliminary assessment framework. Unlike the renourishment alternatives assessed for Florida, many of the construction aggregate alternatives in the Antillean framework did not involve marine ecological effects. Therefore the Antillean framework focused upon a broader range of potential ecological effects than just those associated with marine fishes. Preliminary information was derived from a variety of unpublished

Figure 1 Overview of the Three Stages of a Comparative Ecological Risk Assessment and Primary Components Within Each Stage.

Based on Harwell *et al.*, 1995, and EPA, 1992. The framework is designed to be flexible; specific assessments may show some differences in structuring.

PROBLEM FORMULATION

Stress Characterization
- Types
- Properties
- Distributions

Effects Characterization
- Types
- Properties
- Distributions

⇓

Ecosystem Susceptibility and Stress Co-occurrence

⇓

Endpoint and Indicator Selection

⇓

Conceptual Model

⇓

ANALYSIS

Stress Characterization ⇓ | Effects Characterization ⇓

Distribution Patterns ↔ Ecosystem Characterization ↔ Effects Data Evaluation

Distribution Patterns ⇓ Exposure Analysis ⇓ Exposure Profile

Effects Data Evaluation ⇓ Ecological Response Analysis ⇓ Stressor-Response Analysis

⇓

RISK CHARACTERIZATION

Risk Integration

Integration ↔ Uncertainty

⇓

Risk Description
- Ecological Significance
- Risk Summary

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sources, as well as Green and Cambers (1991). This is a *preliminary* framework for large-scale CERA-based assessments which may focus on one or many of these alternatives. Iterative revisions are encouraged.

Decision Support Frameworks

To aid decision-making among the alternative policy choices and complex technical attributes of beach systems, analytical hierarchy procedures (AHP) were used to categorize system complexities and evaluate key factors and nested subcomponents (Saaty, 1986; Golden *et al.*, 1989). AHP analyses contain several fundamental attributes. A hierarchic structure is developed which consists of a primary goal containing nested criteria of increasing specificity. Top-down these levels include criteria, subcriteria (possibly occupying several levels), and alternatives at the terminal level. Nodes within each level may contain up to 9 nodes in the subsequent level. Criteria and subcriteria are assigned differing weights relative to other factors at each respective level. Instead of assigning numbers to simultaneously rank one alternative versus all others, pairwise comparisons are executed for all criteria, and nested subcriteria, developed within the hierarchy. These relative comparisons represent ratio scales, not only averaged ranks, and can accommodate both qualitative and quantitative information. This allows evaluations of multiple factors separately, and ultimately, appropriate combination into a single ratio scale value for each alternative (Saaty, 1986; 1996).

AHP analyses were included within the integration subcomponent of the risk characterization stage of the Florida assessment as a multi-objective solution procedure (*sensu* Keyes and Palmer, 1993) using Windows-based software (*Expert Choice*™). This software allows resource managers to structure and execute hundreds of quantitative and qualitative assessments simultaneously to evaluate alternatives and rapidly calculate summary values (Schmoldt *et al.*, 1994). Such hierarchic structures are flexible and can be modified to incorporate dynamic circumstances or opinions of differing experts. Comparative analyses were guided by data matrices produced from the analysis and risk characterization phases of the preliminary Florida CERA which integrated primary factors reflecting environmental impact with all of the policy alternatives. Sensitivity analyses (performance-type) were employed to evaluate the effects of differing weighting schemes upon model outcomes. These analytic processes are iterative. The model structures, data matrices, and their decision outcomes will evolve with increasing insight into the complex biological and technological attributes of beach system management within each of the regions examined. In addition, AHP methods have been used in combination with other approaches, including linear programming and multi-objective programming (Schmoldt, *et al,* 1994). Other decision-support approaches are available (Keyes and Palmer, 1993; Peterson *et al.*, 1994), and may independently prove more applicable to the present issues. However, given the prior successful applications of AHP methods, their ease of use, and the lack of any decision-support methods within the arena of beach system environmental management, the use of AHP methods in preliminary applications appears to be warranted.

Geographic Frameworks

Several differing beach systems are represented among the 35 Florida counties with marine shorelines. The present study focused on the subtropical Atlantic beaches of the southeast and east-central shore of the Florida mainland (in particular, Dade through Martin counties). Antilles refers here to the Caribbean island arc system extending from Cuba through Trinidad. The majority of information was derived from islands of the eastern Caribbean, although beach management issues in Puerto Rico were also considered. These islands possess diverse geomorphologies (ranging from low islands with carbonate beaches to high islands with igneous beaches) which greatly influence specific attributes of ecological assessment procedures.

RESULTS

Comparisons of physical and management attributes of beach systems of Florida and the Antilles are summarized in Table 1. Of primary significance to the present study is the fundamentally different way in which sediments are treated as management tools. In Florida, sediments are typically mined from offshore and pumped onto erosional beaches for nourishment, a process occurring uncommonly in the Antilles at the present time. In the Antilles, sediments are mined directly from the beach and transported inland for use as the fundamental component of the aggregate used to produce bricks, concrete and plaster, a process not occurring in Florida, Table 1. In each region, these fundamental strategies have raised many environmental and policy questions and are at the center of substantial management discussions regarding environmental effects, enforcement of protective measures, mitigation, and potential alternatives. Progress on the environmental components of these issues is constrained by the lack of systematic CERA frameworks for ecological assessments. Progress on the policy components is hindered by the lack of systematic decision-support methods for policy formulation.

Preliminary Assessment Framework: Environmental Effects of Florida Beach Management Alternatives

Examples from several sections of a preliminary assessment addressing the effects of differing beach management alternatives upon coastal fishes are provided below. As space limitations preclude inclusion of all sections (see Lindeman, in prep. for additional details), emphasis was placed on characterizations of potential stressors and effects associated with each management alternative. It is not possible to characterize all ecological aspects of stressor effects upon all resident and transient fauna subjected to beach management activities. Therefore, CERA methods typically identify representative taxa for particularly detailed evaluation. In the present example, early life stages of economically and ecologically valuable fishes were chosen as the representative taxa. Considerable evidence suggests that survivorship of early life stages is a key determinant of ultimate adult population sizes (Sale, 1991; Richards and Lindeman, 1987; Doherty and Williams, 1988). Therefore, early demersal life stages were emphasized in

Table 1 Comparative Aspects of Beach Systems and Their Management in Florida and the Antilles.
Broad region-scale characterizations only; local-scale variations can occur.

Beach Systems of Florida and the Antilles

Differences

Physical and Biotic Characteristics	Florida	Antilles
Beach sediment budgets:	Highly erosional[1]	Less erosional
Sediment sources and types	$CaCO_3$ and quartz	$CaCO_3$ or igneous
Sediment transport regimes	Longshore/CS[2]	CS/Longshore
Shelf type	Continental	Insular
Management Characteristics		
Administrative infrastructures	Large	Small
Economics of local beach users	Well-developed	Developing

Florida Beach Management:
Mechanically add sediment to beach via offshore and inshore mining
Result: sediments redistributed across shelf by large-scale dredging and resuspension

Antillean Beach Management:
Mechanically remove sediment from beach via beachface and backdune mining
Result: sediments completely removed from system

Similarities

Physical and Biotic Characteristics
- Climate: Tropical/subtropical (wet/dry seasons, hurricanes)
- Biodiversity: High
- Complex beach dynamics: Continuous abiotic/biotic monitoring needed

Management Characteristics
- Tourism-based economies
- Construction setbacks legislated, but often waived
- Environmental assessments often lack cumulative perspective
- Agencies often lack systematic framework for policy decision-making
- Shoreline armoring common

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1 - Accelerated by artificial inlets which remove sediments from the inshore system.
2 - CS = Cross-shelf

evaluations of potential effects.

Stressor Characterizations

Ten individual management alternatives designed to retain or renourish erosional beaches (collectively termed nourishment in the present study) of Florida were considered in the following summaries. The ten alternatives were placed within two categories, sedimentary deposition and structural, Table 2. Three fundamental categories of stressors were identified: turbidity, sedimentation (burial), and direct mechanical impacts. The specific stressors are largely dependent on the engineering characteristics of each alternative. These characteristics are summarized below.

Sedimentary Deposition Alternatives:

Dredge & Fill - Renourishment

Large-scale beach dredge projects in southeast Florida are based on the excavation of sediments from midshelf areas (1-6 km offshore) and the dumping of the fill on shorelines where it is bulldozed into a broad beach. When first done on a highly eroded shore, they are termed "restorations". Most involve the excavation and dumping of up to 1,500,000 yd^3 of sediments per project. In practice, follow-up dredge projects, termed "renourishments", are usually incorporated into the original engineering design at 5-10 year intervals.

- Dredge & Fill - Inlet Maintenance

Approximately nine of eleven inlets of southeast Florida are periodically dredged to reduce shoaling. These projects involve smaller dredges and smaller fill volumes (typically between 25,000-150,000 yd^3) than beach renourishments. The fill is typically pumped to the south side of the inlet's south jetty where slurry is discharged and redistributed with bulldozers on the upper beachface.

- Dredge & Fill - Nearshore Berms

A new alternative for south Florida, nearshore berm construction, is now under evaluation (ACOE, 1996). This technology is an engineering variation of large-scale offshore dredge and fill, wherein the fill is dumped in nearshore waters instead of onshore. Such shallow-water berms (3-5 m depths) can attenuate incoming wave energy and/or act as feeders for beach sand to migrate seawards.

- Quarry Trucking

Trucking of sand from inland quarries has been done in the past on some smaller projects.

Table 2 Summary of Selected Components of Stressor and Effect Characterizations in Preliminary Environmental Assessment of Florida Beach Nourishment Alternatives.

Nourishment Alternatives:

Sedimentary Deposition Technology		Structural Technology	
DR	**D**redge and Fill: **R**enourishment	**SW**	**S**eawalls & Revetments
DB	**D**redge and Fill: Nearshore **B**erms	**GJ**	**G**roins & **J**etties
DI	**D**redge and Fill: **I**nlet Maintenance	**BR**	**Br**eakwaters
QT	**Q**uarry Sediments by **T**rucking	**BD**	**B**eachface **D**ewatering
AB	**A**ragonite Sediments by **B**arging		
ST	Inlet **S**and **T**ransfer Plants		

Primary Stressor Categories:

• Sedimentation • Turbidity • Mechanical

Spatial Scale of Stressor Distribution:

• Nearshore • Intermediate • Midshelf

Indicator Taxa & Ecological Endpoints:

• Ecologically/Economically Valuable Fishes (early life stage focus)

• Diversity • Habitat Amt. • Nursery Value

Examples of Lethal & Sublethal Effects:

Intensity of Effects		Duration of Effects: Short-term	Duration of Effects: Long-term
	Lethal	• Burial of species fleeing to crevices [1] • Respiratory trauma [2] (erosion of gill filaments)	Loss of settlement habitat [1,3] resulting in: • Increased predation • Increased starvation
	Sub-lethal	• Respiratory stress [2] • Separation from conspecific schools [2]	• Reduction in growth * • Residence in new, suboptimal habitat *

Stressor inducing the effect:
[1] - Sedimentation (burial)
[2] - Turbidity
[3] - Mechanical impacts
* - Potentially, combinations of all

Large-scale trucking of inland quarry sands to deposit on south Florida beaches has not commonly occurred in recent years. Costs and logistics have been considered prohibitive.

- Aragonite Barging

The barging of aragonite sediments from existing mining operations on the Grand Bahamas shelf, to southeast Florida from the Bahamas has recently received considerable attention. Only one small project (25,000 yds^3) at Fisher Island, Dade County, has been constructed in Southeast Florida.

- Sand Transfer Plants

Inlet bypassing using sand transfer plants (STP's) is also receiving substantial management attention. STP's are fixed sediment pumping stations situated in shallow water on the accretionary sides of inlet jetties (the north sides in southeast Florida). They use submerged pipes under the inlet to pump naturally accreted sediments from the north sides of the northern jetties to the south sides of the southern jetties where the sand is deposited from a discharge pipe. Only two STP's, at Lake Worth Inlet and S. Lake Worth Inlet, exist in the study area. Both are decades old and have been functioning poorly or not at all in recent years.

Structural Alternatives

The first two alternatives in this category, collectively termed shoreline armoring, have been employed for beach management world-wide for decades. The latter two have only recently received serious consideration as beach management alternatives in southeast Florida.

- Seawalls & Revetments:

These are structures which are parallel, and connected, to the beachface. Seawalls (bulkheads) are typically vertical, whereas revetments are typically oblique. They are usually designed to support the foundation of developed property and to deflect wave actions.

- Groins & Jetties:

These structures are perpendicular, and connected, to the beachface. Jetties are placed individually, or in pairs, at the mouths of inlets and channels to reduce shoaling. Groins are typically placed away from inlets, often in series (groin-fields), to trap sand in front of specific target areas.

- Breakwaters - Submerged & Emergent:

Although parallel to shore, these structures are not shore-attached. They are placed at distances of 15-150 m offshore in one or more parallel arrays and are designed to reduce wave energy, and therefore, erosion of the leeward beach. In south and central Florida, they have been constructed from concrete modules or boulders. Several submerged breakwaters composed of prefabricated concrete modules have been installed for beach management purposes in the last decade in southeast Florida.

• Barrier Island Dewatering:

Based on soil drainage technology long used in civil engineering, dewatering techniques involve pumping water out from underneath the beachface to tighten surficial sediments and enhance accretion potential.. Only one system has been installed in the study area, at south Hutchinson Island in Martin County.

Effect Characterizations

The diverse biological systems and the varied engineering alternatives examined herein guarantee a high number of potential effects, both direct and indirect. These effects can operate at scales ranging from the organism through the ecosystem. In addition to characterizing effects and consequences at organismal through community scales, discriminating natural background variation from stressor-induced effects is also important.

Types of Effects

Stressors associated with sedimentation, turbidity, and mechanical impacts can effect co-occurring fishes on scales of individual physiology through local population structure. A detailed listing of potential stressor effects upon marine organism physiology and behavior is provided in Eisler (1979). The diversity of potential effects at the individual level is high. For example, seven differing sensory system variables and at least five other variables associated with motor activity and water-column positioning can be affected by dredge burials of resident fish habitats (Lindeman, in prep.). Effects can be direct or indirect and operate over the short-term, long-term, or both. Indirect effects at the individual level can translate into population-level effects cumulatively. Many effects will show some species specificity, and within species, substantial ontogenetic variation. Typically, the earliest life history stages are the most susceptible. Consideration of effects upon fishes at these scales, and their effects upon higher organizational scales, are absent from the literature on beach dredging impacts in Florida. As the majority of fishes using nearshore areas of southeast Florida are early life stages (Lindeman, in prep.) and life stages of many families using mid-shelf areas are typically older, the greatest direct and indirect impacts may occur at nearshore dump sites.

Interactions between subtle, long-term effects may also occur, adding to the complexity in evaluating overall risk. Examination of cumulative effects of both direct and indirect stressors is complex and often unattempted, yet of potentially profound importance to the full understanding of anthropogenic effects (Cocklin *et al.*, 1992; Vestal and Reiser, 1995). To provide an analytical structure for individual and collective examination of these issues, it is useful to discriminate among lethal and sublethal effects which in turn, can produce differing effects based on the time-scale evaluated. Table 2 structures some of these effects using examples which may occur in association with beach dredge and fill activities. As shown, identical organ systems can undergo sublethal or lethal effects (e.g., respiratory stress vs. respiratory trauma). These variations, in turn, lead to differing effects at greater exposure durations. Additional examples can be developed for each combination of stressor intensity and duration. Variations of this framework were used in alternative-specific overviews of stressors and effects (Lindeman, in prep.).

Cross-Shelf Spatial Distributions of Effects

In terms of the spatial distributions of potential stressors and effects, the ten beach engineering alternatives summarized above have a variety of differing distributional characteristics. A productive way to initially stratify coarse distributions of coastal stressors is by use of a cross-shelf perspective. Three overlapping cross-shelf strata are applicable here: nearshore (0-3 m depth), intermediate (3-5 m), and midshelf (5-15 m). The potential for significant stressor occurrence within each of these strata (indicated by an X), from inshore to offshore, was estimated as follows:

Sedimentary Deposition	*Nearshore*	*Intermediate*	*Mid-Shelf*
Dredge/Fill - Restor./Renourish:	X	X	X
Dredge/Fill - Nearshore Berms:	?	X	X
Dredge/Fill - Inlet Maintenance:	X		
Quarry Sediments by Trucking:	X	?	
Aragonite Sediments by Barging:	X		
Inlet Sand Transfer Plants:	X		
Structural			
Seawalls & Revetments:	?		
Groins & Jetties:	X	X	
Breakwaters - Submerged/Emergent:	X	X	
Beachface Dewatering:	X		

Analyses of Stressors and Effects

The mechanical conditions under which many beach engineering operations occur can preclude direct assessment. For example, visual assessment of direct dumping of dredge fill on hardbottom reefs is not possible - often for weeks post-project due to elevated turbidities at, and adjacent to, the project site. This situation also applies to direct assessment of the interface of the dredge cutterhead and substrate during excavation of fill offshore. In addition, most monitoring studies are based on unreplicated field surveys, have not undergone third-party review and are not published in research journals. Overall, the available environmental literature on the majority of the ten possible alternatives, especially those not involving offshore dredging and nearshore filling, is small. In such cases, plausible statements regarding potentially negative (or positive) effects are possible - but on a limited basis - basic environmental information on many of these alternatives is still unavailable.

Due to space limitations, analysis of stressors and effects is only provided for the offshore dredge and fill alternative. Details of the other alternatives are available in Lindeman (in prep). Effect characterizations for large-scale dredging provide an example of how such characterizations can be accomplished.

a) Sedimentation & Turbidity Effects

Midshelf (excavation) areas

The primary references available on dredging effects upon fishes in midshelf areas of southeast Florida is from 1970 and 1971 projects at Pompano and Hallandale, respectively. Qualitative surveys of fishes and invertebrates of reef lines near mid-shelf borrow pits were conducted during, and subsequent to, dredging (Courtenay *et al.*, 1974; 1980). In the first study, dredging effects on site-associated spp. on reefs near borrow sites were not observed. Invertebrate impacts from both sedimentation and mechanical abrasions were observed at sites on the second reef line at Hallandale. Effects upon reefs near the 3 Pompano borrow pits were not observed. The latter study was conducted in the Hallandale area only during 1978-79 via follow-up surveys of areas near 1971 dredge sites. The primary ichthyofaunal conclusion was that the dusky jawfish, *Opistognathus whitehursti*, was eliminated locally by incursion of borrow-derived sediments upon the first reef line. As various factors (e.g., natural variations in larval recruitment or local survivorship) may have intervened in the seven year interval, this conclusion is best considered a hypothesis. As approximately 35 offshore dredge projects for beachfill have been executed in the four county study area between 1970 and 1996 (ACOE, 1996; Lindeman, in prep.), it is remarkable that no replicated, peer-reviewed journal publications on the effects upon fishes exist.

Due to the excavation and pumping of 100,000's of cubic yards of sediments during offshore dredging, turbidity clouds are created which extend downstream and cross-shelf for kilometers, and throughout the vertical water column. Turbidity may be most concentrated at the excavation site of cutterhead dredges or at the site of slurry overflow at hopper dredge barges. Heavier sediments settle out, stressing corals and other sessile invertebrates. Typically, gorgonians and sponges tolerate sedimentation stress better than scleractinian corals (Goldberg, 1988). Wilber and Stern (1992) estimated recovery times for borrow site infauna of at least 4-5 years at one project.

Ultimately, dredge-suspended sediments are distributed throughout cross-shelf areas between the excavation and dumping sites and downstream from prevailing flow-fields. Semi-continuous resuspension events of dredge fill sediments by wind and waves can realistically occur over years. This could potentially result in long-term elevation of turbidities in some areas. At least 100 cross-shelf dredging projects may occur between 1969 and 2050, involving the excavation and dumping of at least 100,000,000 yd^3 within a 4 mile by 120 mile corridor between Dade and Martin counties alone (ACOE, 1996; Lindeman, in prep.). Therefore, repetitive, large-scale dredging may result in chronically elevated turbidities on both local and regional scales. Evidence of chronic wind and wave-induced sediment resuspension which lowers mean water clarity can be seen along the entire length of Jupiter Island, Florida, the site of 8 large renourishments in 22 years (Lindeman, in prep.; D. Snyder and K. Lindeman, pers. obs.). Population responses of various organisms to reductions in water quality from chronic turbidity may operate at time scales of decades, masking effects which may be cumulatively substantial. This scenario is at least as plausible as the common assumption that negative effects of large-scale dredging are short-term, if at all.

Intermediate Areas (Pipeline Path)

Leaks from the seams between pipes transporting dredge fill along the benthos could result in effects on nearby fishes and invertebrates. These effects are probably quite limited. During dredging operations, sediments are suspended from excavation areas and dispersed to intermediate cross-shelf areas. Potential effects in the short term, and chronic resuspension in the long-term, discussed in the above section on fish effects at mid-shelf areas, also apply here.

Onshore/Nearshore Areas (Dump Site)

There are no published studies which address the dumping of large volumes of dredge fill upon fishes of nearshore habitats of Florida, either hardbottom or softbottom. As several dozen acres of nearshore reefs are estimated to be buried or impacted by past beach dredging operations (Lindeman, in prep.) and approx. 61 additional acres of direct reef impacts are estimated in the 50 year ACOE plan (1996) for Dade through Palm Beach counties alone, the absence of published research is problematic. Factors related to both sedimentation (effects upon settlement) and turbidity (effects in suspension) can have both direct and indirect effects upon fishes. In addition to large scale anthropogenic pulsing, such factors require evaluation relative to natural background levels.

Administrative environmental reviews of fish impacts typically assume that fishes will simply swim away from dredge dumping, or will only be temporarily displaced. However, many of the species of nearshore reefs are represented primarily by life stages which are site-attached at the time of habitat elimination. These include newly settled stages of grunts, snappers, and high hats, and all life stages of damselfishes, clinids and gobies. These and other species which characterize ichthyofaunal compositions of natural and artificial nearshore reefs of southeast Florida (Lindeman, in prep.; Lindeman, 1996), can't simply swim away in many cases. They may try, but such life stages are not adapted for extended flight behaviors and subsequent vagrancy (e.g., grunts are morphologically and ecologically adapted to utilize structural habitats for daytime shelter, Lindeman, 1986). Fundamental questions of physiological thresholds, flight behaviors, ontogenetic variation in effects, reduction of growth, increases in predation, and synergistic effects upon local adult population sizes are unaddressed over both short- and long-term time scales. For both juvenile and adult fauna adapted for site-attachment at the time of large-scale burial, assumptions of temporary displacement may be leaps of faith, as much as tenable hypotheses. Logistic difficulties in detailing direct or indirect mortalities of individual fishes in water made anthropogenically opaque for months don't strengthen the null hypothesis of no, or limited fish mortality from such burials. More realistic hypotheses would focus on coarse estimations of mortality based on mobility-based groupings of fish taxa (Lindeman, in prep). In addition to the limited data on direct mortality, indirect effects are entirely unknown.

b) Mechanical Habitat Effects

These effects are based on physical modification of habitat structure (direct fill burial is treated under sedimentation). Although directly affecting many invertebrates, these effects are primarily indirect for fishes. No studies of such effects exist for fishes in Florida. Such research will require linkage of habitat losses/modifications to organismal or population scale effects.

Midshelf (Excavation) Areas

Cutterhead dredges mechanically disrupt the bottom and physically remove bottom sediments and on-site fauna, digging as deep as 35'. Trailing suction heads of hopper dredges remove surficial sediments and infauna, but with reduced volume and depth compared to cutterheads. Despite putative buffer zones between dredges and reefs, cutterhead dredges and associated construction equipment (e.g., discharge pipelines, mooring chains) can mechanically damage hardbottom areas as in projects at Sunny Isles (Blair *et al.*, 1990) and Boca Raton (Barry, et al, 1990). Although, more care is taken during planning and excavation periods, small buffer zones (150-400') are often used, and better positioning systems (GIS) exist, the sheer number of new projects, the on-site realities of marine construction activities, and the reduced availability of sand suggests that direct mechanical effects are not a past issue and require continued examination.

Intermediate Cross-Shelf Areas (Pipeline Path)

36" to 24" diameter pipelines are typically used to transport hydraulically pumped, newly excavated fill across-shelf to the dump site. There are many precedents for these pipelines to be laid directly across hardbottom or to be moved in storms. In either case, damage to hardbottom structures can occur.

Onshore/Nearshore Areas (Dump Site)

Direct burial and subsequent abrasion effects are evaluated under the Sedimentation and Turbidity Effects section above.

Integration and Characterization of Management Alternatives

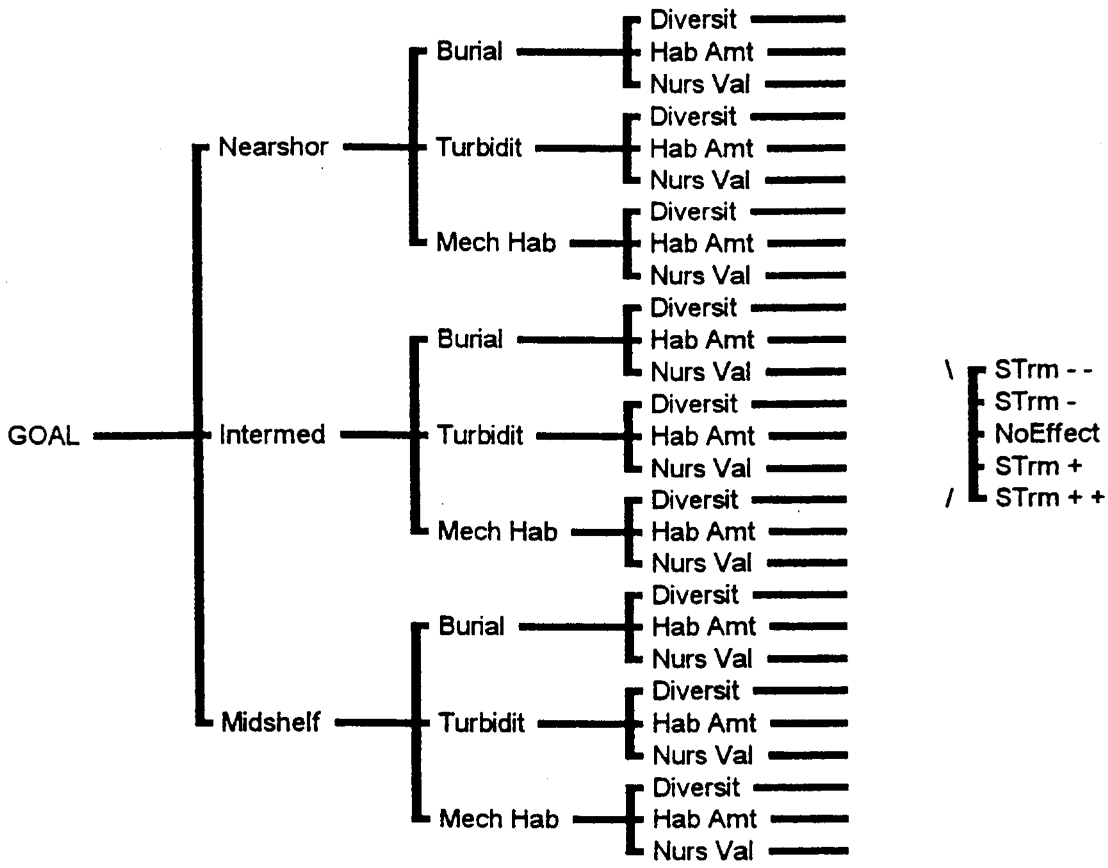
Analytic Hierarchy Components and Assessment

The analytic framework was based on a hierarchy consisting of a primary goal containing nested criteria of increasing specificity. The operational project goal was defined as: *optimal environmental management of southeast Florida beach systems*. After preliminary analyses of several hierarchic structures, a ratings model was ultimately chosen as the primary analytical model, Figure 2. Ratings models separate the alternatives (ten total in this case) from the model structure and compare them against sets of standards which occupy the terminal model nodes. In this case, the standards represented a scale of estimated environmental effects upon fishes. For all criteria above the terminal node, weights were calculated by pairwise comparisons. With the current project goal, the ratings approach fostered more logical consistency and confidence in the assignment of ranks according to standards based on existing knowledge. Also, the integration of ecological endpoints and indicators was enhanced in the ratings model, as they fit logically as the penultimate node between the effects-defined criteria and the standards. Therefore, the structure of the ratings model proceeded from *cross-shelf spatial scales* (3 nodes), to *effect types* (3 nodes), to *ecological endpoints* (3 nodes), and terminated at a range of *standards* (left to right in Figure 2).

The standards consisted of 5 estimates of short term environmental effects: highly negative (Strm --), negative (Strm -), no effect (No Effect), positive (Strm +), highly positive (Strm ++). Comparisons among alternatives involved assignment of one of these five effect estimators for each alternative within each criteria path. As there were three criteria with three nested nodes above the standards, 27 total criteria paths (defined by nested combinations of cross-shelf distributions, impact types, and ecological indicators) by 10 alternatives produced a total of 270 individual effect estimations in the full analysis. At higher levels of the model (cross-shelf spatial scales through ecological endpoints) priorities were based on pairwise comparisons of the relative importance of differing nodes within each criterion level. Nearshore and midshelf areas were considered the most important nodes within the cross-shelf spatial scale criterion, while intermediate areas were considered less important. Therefore, at this level, the former two nodes were given weights of .4 and the latter, a weight of 0.2. All factors within the effect type and ecological endpoint levels were weighted equally.

Figure 2 Analytical Hierarchy Based on Ratings Model Comparisons with Three Criteria.

With a set of five environmental standards terminally nested within each criteria path (ranging from very negative = Strm--, to very positive = Strm++. The number in parentheses are the weights of each factor relative to all other factors within the same level of the hierarchy. The ten engineering alternatives, Table 2, are situated outside the formal hierarchy but are still ranked according to the standards.



Model Results

Comparisons of estimated environmental effects of ten engineering alternatives were performed using the ratings structure described above. This preliminary analysis included alternatives within the two differing categories of Sedimentary Deposition Technology (SD) and Structural Technology (SL), discussed above. The results are given in Figure 3. Due to the lack of detailed consideration of effects elsewhere, and their direct societal importance, effects upon fishes only were evaluated at this stage. Future applications of such analyses to other organisms, and the full breadth of other higher level factors (e.g., engineering, economics) are discussed in Lindeman (in prep).

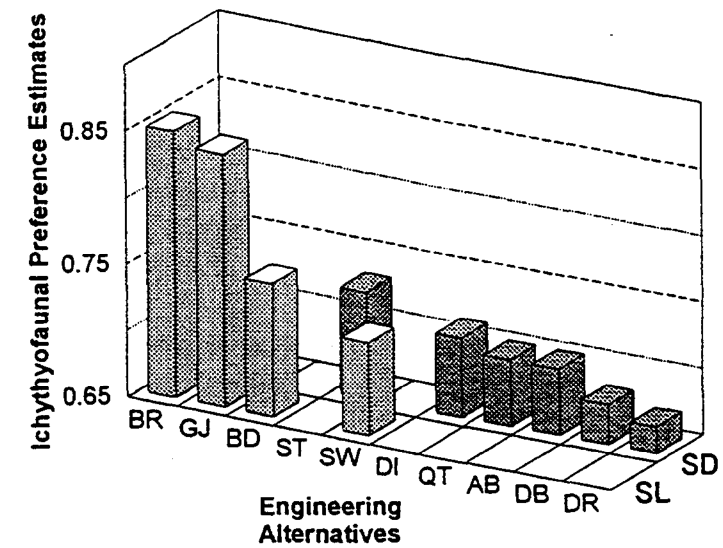
The three most favorable alternatives in this preliminary analysis were breakwaters, groin fields/jetties, and beach dewatering systems, Figure 3. The former two alternatives ranked high due to a variety of positive ichthyofaunal attributes. The latter alternative, and those ranked fourth and fifth, were characterized by basically neutral ichthyofaunal effects. The remaining alternatives reflected increasingly higher intensities of negative ichthyofaunal effects (Lindeman, in prep.). The highest rated SD technology was sand transfer plants. The lowest rated SD technologies were offshore dredge/inshore fill operations (restorations/renourishments) and nearshore berms, Figure 3.

Sensitivity analyses proved useful in examining criterion-specific weighting effects upon total ranks (Saaty and Vargas, 1994). As almost all SD technologies ranked more negative for environmental effects than SL technologies and are often considered more routinely in planning processes, SD results are emphasized here, Figure 4A. What-if analyses on SD technology alternatives are given in Figure 4B (weights skewed to mid-shelf areas). These results ranked sand transfer plants highest in terms of environmental preference no matter how weights of cross-shelf areas were varied, although the spread between alternatives was reduced by increased weighting of the midshelf spatial scale, Figure 4B. This consistency of high ranks for sand transfer plants was primarily due to no negative effects upon the ecological indicators examined. Once operational, such systems are economically competitive with dredging, create no substantial environmental problems anywhere across the shelf, keep nearshore sediments out of inlets, reduce the need for both inlet and renourishment dredging, and therefore, reduce the concentration of silts and clays in shallow waters. The current ACOE plans to refurbish two plants are endorsed. Due to long-term economic and environmental issues, and shortages of beach compatible sand from offshore dredge areas, planning to construct several additional sand transfer plants on the east coast of Florida is suggested.

The least preferred technologies from AHP analyses of ichthyofaunal effects among SD technologies were offshore dredging and inshore filling (restoration/renourishment) and dredging to create nearshore berms. Although rankings were based on short-term factors, a variety of long-term consequences of repetitive dredging and dumping are possible (discussed above). The negative rankings of these two alternatives was based on potential effects across multiple cross-

Figure 3 Summary of Analytical Hierarchy Analysis of Estimated Ichthyofaunal Effects of Ten Engineering Alternatives for Beach Management in Florida.

Engineering Alternatives	Engineer. Categories	SD Totals	SL Totals
BR	SD		0.85
GJ	SL		0.84
BD			0.75
ST		0.73	
SW			0.72
DI		0.71	
QT		0.7	
AB		0.7	
DB		0.68	
DR		0.67	



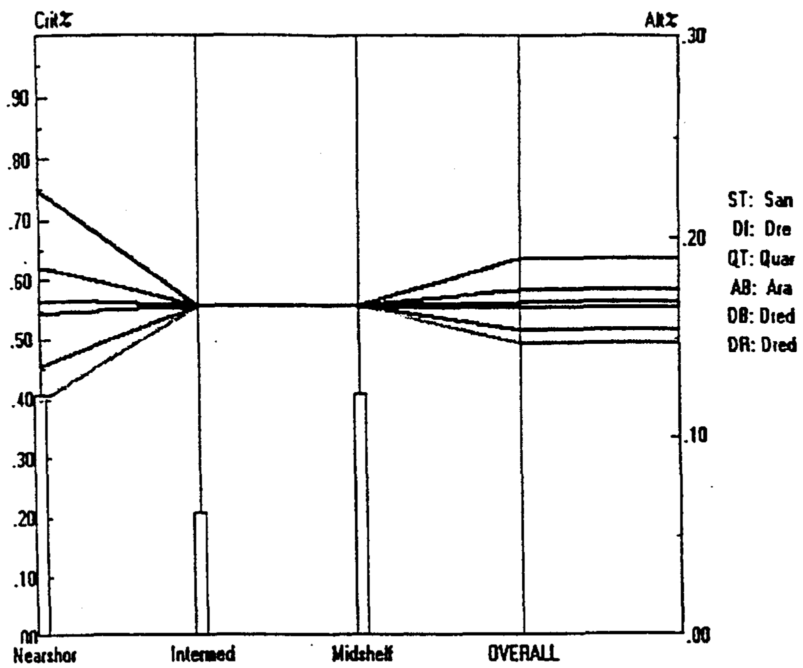
Sedimentary Deposition Technologies (SD)
DR: Dredge - Renour./Restor.
DB: Dredge - Nearshore Berms
DI: Dredge - Inlet Maintenance
QT: Quarry Trucking of Sand
AB: Aragonite Barging
ST: Sand Transfer Plant

Structural Technologies (SL)
SW: Sea Walls/Revetments
GJ: Groin Fields/Jetties
BR: Breakwaters
BD: Beach Dewatering

Figure 4 Sensitivity Analyses of AHP Results Among Six Types of Sedimentary Deposition Alternatives.

a) Nearshore and midshelf spatial scales equally weighted. b) What-if results with weighting of cross-shelf strata skewed to midshelf. Weights of criteria are represented by the heights of the vertical bars against the left axis. Relative preferences of differing alternatives are represented by horizontal lines The overall value for each alternative is on the right axis.

A.



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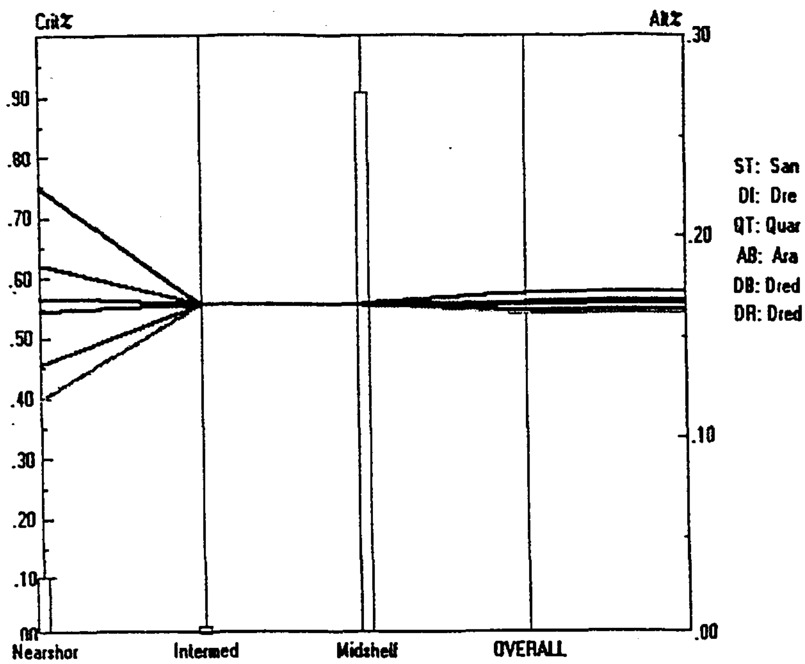


shelf scales, and therefore, did not improve with varying weighting of cross-shelf areas, Figure 4.

Uncertainties and Monitoring Needs

Differing weights will be assigned by different experts throughout the criteria nodes of models of this complexity. Iterative development is essential for full maturation of this preliminary framework. Additionally, group-based methods to flesh out diverse opinions and subsequently build consensus models (e.g., Delphi methods discussed in Titus and Narayanan, 1995, Saaty and Vargas, 1994) should be applied not only to fishes, but to the breadth of taxa within nearshore coastal areas. For example, sea turtles will show different ranks in relationship to seawalls than fishes. Ultimately, AHP or other multi-criteria decision tools should be developed to encompass multiple policy criteria, particularly the engineering and economic attributes of potential alternatives. In a comprehensive policy hierarchy, these latter criteria will be weighted higher than environmental factors.

Although originally attempted in the pure pairwise comparison model, an effect duration criterion which included long term effects could not be inserted into the current decision-support structuring. There are still too few cumulative data available on effects. With initiation of long-term monitoring programs, cumulative information could become available and this critical aspect of ecological assessment can be examined in more formal fashions. Of substantial long-term importance are the potential cumulative effects of chronic turbidity via wind- and wave-induced resuspension of dredged sediments. Arrays of nephelometers over regional scales would permit long-term separation of dredge-induced turbidity and resuspension from natural background levels. An aerial imagery database from planes or satellites may substantially aid predictive evaluations of physical and biological effects of these massive dredging projects. Predictive knowledge of local and mesoscale dynamics of sediment behavior, and population responses of organisms, will be delayed until long-term, mesoscale information is acquired.

Preliminary Environmental Assessment and Decision-Support Frameworks: Sand Aggregate Alternatives in the Antilles

Based on a fundamental issue in Antillean beach management, the goal of the present example is to *outline* systematic approaches for identifying the optimal alternative, or combination of alternatives, to provide aggregate for construction purposes. Detailed decision-support analyses and ecological risk assessments, based on revised versions of this framework, will be required for future *identification* of optimal alternatives. A representative range of alternatives available for construction aggregate is given in Table 3. These eight alternatives can be organized into three categories based on ultimate origin of aggregate: terrestrial mining, submerged dredging, and importation. Many small island developing states (SIDS) may not have all of these alternatives, while larger islands (e.g., Puerto Rico) will. The framework constructed here is inclusive of all islands types. Comprehensive analyses for many SIDS may involve fewer alternatives and should usually be island-specific.

Table 3. Representative Alternatives Available for Construction Aggregate in the Antilles.

Terrestrial Mining	Submerged Dredging	Importation
Beachface Mining	Offshore Dredging	Importation from off-island
Backdune Mining	Navigational Channel Dredging	
Inland Mining - Quarries	River Dredging	

Selected Assessment Issues - Antillean Framework

Large-scale ecological risk assessments of multiple alternatives for construction aggregate will require simultaneous characterization of primary stressors and biological effects. Stressor characterizations will largely depend on the engineering characteristics of each alternative, while potential effects will be largely based on the habitat and organisms co-occurring with a particular alternative. Diverse sources of aggregate are potentially available on some larger islands, including inland quarries, rivers, beaches and offshore deposits. Assessments which evaluate the full range of alternatives on such islands will require substantial knowledge of terrestrial and fresh water organisms and processes, as well as marine. The importation of aggregate from off-island sources within or outside of the Antilles also raises ecological risk issues. These include the need for quarantines of aggregate from some exporting countries (M. Porter, pers. comm.) or excavation and transport effects at the exporters source area. Several alternatives of particular relevance to coastal marine areas are considered below.

One alternative common to many nations of the region is the mining of beachface areas to directly obtain aggregate for construction. Substantial environmental and public safety problems may result from the cumulative removal of this fundamental ocean-land interface. Recently, considerable efforts have been taken by almost every Antillean nation to eliminate or regulate this practice. Enforcement of such regulations is the true test of governmental commitment to these new policies. Many islands of the region have made admirable progress in this regard. Unfortunately, many islands have few other alternatives readily available and beach mining, regulated or not, remains a key source of aggregate. A CERA approach to an EIA for beachface sandmining activities should include sea turtles if nesting beaches are affected, in addition to any substantial terrestrial effects.

Due to the diminishing role of sand mining as an aggregate source, interest in mining offshore sediments via dredge operations is growing. Although offshore dredging for aggregate has rarely occurred in this region, dredging activities which could induce similar environmental stressors have. Inshore, such activities include the dredging of marinas or port entrances for navigational maintenance purposes (with dredged material used as aggregate or as beachfill). Offshore, such activities include the dredging of fill material for beach nourishment, Table 4. Although published information from the Antilles on direct dredging effects is limited, Bak (1978) demonstrated both lethal and sublethal effects upon several genera of stony corals in Curaçao. Dodge et al. (1974) demonstrated that natural resuspension of sediments decreased coral growth in Jamaica, indirect evidence that anthropogenic increases in turbidity may effect coral reefs negatively. Some of the literature on the environmental effects of offshore dredging of carbonate sediments in subtropical areas of Florida is applicable to Antillean SIDS (e.g., Marszalek, 1981; Nelson, 1985; Blair *et al*, 1991; Fisher *et al.*, 1992). However, information from many other reports - both monitoring and EIA (typically environmental impact statements mandated by the U. S. National Environmental Policy Act), are not published in peer-review journals, suffer from inadequate survey designs (see Osenberg and Schmitt, 1996, for a recent review of problems with impact studies) or EIA frameworks which do not thoroughly evaluate stressors, effects, or cumulative impacts. All of these factors reinforce the need for detailed, cumulative-oriented EIA's in the Antilles, particularly as offshore dredge projects are an increasingly attractive alternative source of construction aggregate.

Selected Decision Support Issues - Antillean Framework

In the prior section, primary alternatives for construction aggregate in the Antilles were identified. Subsequently, a preliminary analytic hierarchy representing the primary factors determining the optimal aggregate, using nested levels of criteria and subcriteria, was constructed, Figure 5. Based on preliminary analyses and existing evaluations of construction aggregate sources, particularly sand mining of beaches (Green and Cambers, 1991; Cambers and James, 1994), two primary criteria were identified: economic and environmental. In applied policy formulation, economic issues typically outweigh environmental issues. Therefore, within the two primary criteria, economic issues were given a weight of 0.75, while environmental issues were given a weight of 0.25. The economic criterion includes several factors (availability, quality of aggregate) that could arguably be placed in a third criterion, engineering. As stated previously, AHP procedures involving policy decisions are best conducted by group decision-making. Exact placement of criteria in the future should be based on group-consensus.

In the current framework, both the economic and environmental criteria contain four subcriteria each, Figure 5. The economic subcriteria are cost of aggregate per standard unit, availability in the future, quality for construction purposes, and social desirability. Cost was considered the most important factor within the economic criterion. Environmental subcriteria were based on general stressor/effect categories which could effect either aquatic or terrestrial biota. These subcriteria included: air pollution effects (primarily terrestrial effects), mechanical

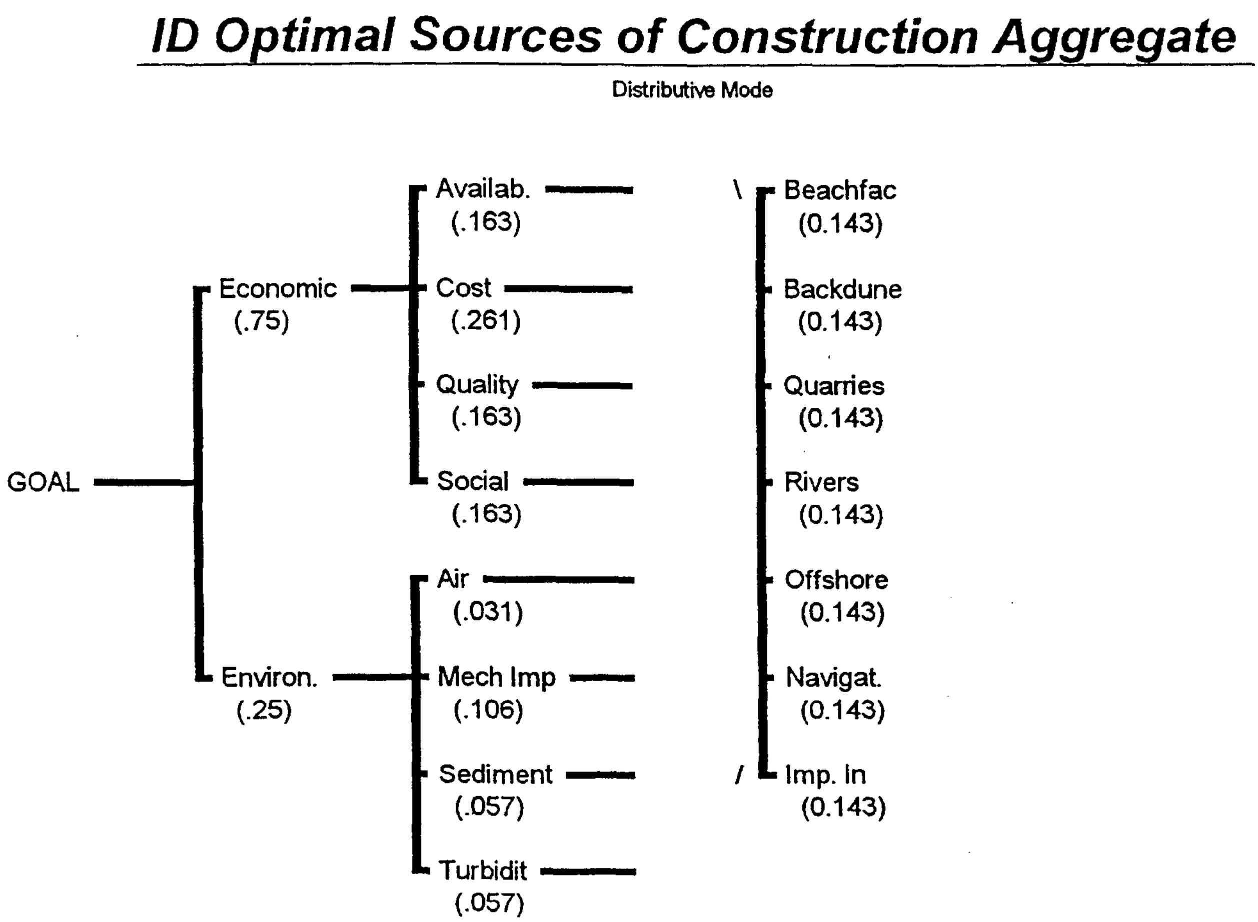
Table 4. Preliminary Summary of Marine Dredging Activities For Beachfill at Selected Antillean Islands.

Comprehensive regional data is currently unavailable. Examples of substantial marine dredging/filling for airport runways or other industrial sites are also included.

Country	Primary Beach-fill Sources	Frequency	Volume (~ yd^3)	Project Information
Anguilla	Offshore	Uncommon	30,000	Hotel shore, after hurricane Louis, 1995.
Antigua	Inshore	Uncommon	-	Marina-derived fill used for both beach and aggregate.
Barbados	Inshore	Uncommon	-	-
British Virgin Islands	Offshore	Uncommon	10,000	Hotel shore, after hurricane Hugo, 1989.
Grenada	Not done?	-	-	Substantial offshore dredging for airport fill.
Montserrat	Not done?	-	-	-
St. Kitts & Nevis	Offshore	Occasional	12,000; 95,000	Two differing hotel shores recently filled.
Puerto Rico	Inshore	Uncommon	Variable	Channel dredge material used for beachfill.
St. Lucia	Inshore	Occasional	-	Recent dredging for beachfill at 2 different sites.
St. Vincent & Grenadines	Not done?	Pending?	-	Substantial offshore dredging for airport fill.
Trinidad & Tobago	Not done?	-	-	Substantial dredging for fill for industrial sites.
Turks & Caicos	Not done?	Pending?	-	Feasibility studies underway.
U. S. Virgin Islands	Inshore, and imported from BVI	Uncommon	-	Also, airport runway extension - mountain sediments used to fill depths up to 90'.

Figure 5 Preliminary Hierarchy for Antillean Aggregate Source Example

The seven alternatives are on the far right and insert into the terminal nodes of each terminal subcriterion. The numbers in parentheses are the weights of each factor relative to all other factors within the same level of the hierarchy. See text for further details.



effects on-site (aquatic or terrestrial), sedimentation effects (aquatic), and turbidity effects (aquatic). Due to their differing relevance among the various alternatives, pairwise ranking of these criteria was difficult. Ultimately, mechanical effects were rated highest (in part due to their relevance at sea or on land), sedimentation and turbidity were ranked intermediate, and air discharges were ranked lowest. Weights which reflect the relative importance of each subcriterion towards achievement of the overall goal are given in Figure 5. Detailed evaluation of alternative-specific biological effects will require the evaluation of representative taxa. The four environmental subcriteria could potentially effect from one to four general faunal types: fishes, invertebrates, reptiles/amphibians, and birds.

With the identification of alternatives, construction of a full hierarchy, and weighting of component criteria, the actual pairwise assessment of all alternatives within all terminal nodes of the hierarchy is possible. The preliminary hierarchy constructed here contained eight terminal nodes and seven alternatives requiring 21 individual inter-alternative comparisons within each terminal node (a total of 168 comparisons overall). Subsequent to the final pairwise comparison process, *Expert Choice* software executes the synthesis step producing final preference values for all alternatives, and sensitivity analyses allowing dissection of the role of individual factors and predictive what-if analyses. Modification of the model to reflect outside expert opinion, insight gained from the initial execution of the entire process, or dynamic circumstances, is a fundamental component of the "end" of each decision-analysis cycle. In the present study, we have not executed the final analytic components described in this paragraph. This step should be taken after group decision exercises are conducted which generate a hierarchy structure, and pairwise comparison process, specific to the criteria and subcriteria of individual islands.

DISCUSSION

Comparisons of Florida and the Antilles

One of the most substantial differences in beach system management between Florida and the Antilles involves the fundamental approach towards sediment management. Although both approaches have recently emphasized mining of sediments, the sites and destinations are radically different. In Florida, sand is dredged from offshore and dumped on beachfaces, while in the Antilles it is mined from beachfaces and used as construction material. Comparatively, relative positives and negatives exist for both approaches. For example, in terms of sediment management the approach in Florida is "better" than the Antilles - at least the sand isn't permanently removed from the system. On the other hand, in terms of marine ecology, Florida is worse than the Antilles - massive benthic disturbances are semi-continuously introduced into coastal waters areas with little consideration of long term effects. In both cases, beachfaces are subjected to substantial artificial modification: either by partial or complete removal, or by semi-continuous burial with dredge fill. These differences in sediment management approaches are perhaps due more to regional variation in geology and hydrodynamics than to management philosophies (Table 1). For example, despite limited statutory and administrative infrastructures, control of coastal building construction is based on setback lines in almost all Antillean nations, very similar to the approach used in Florida.

The present study developed examples of how optimal policy alternatives, individually or in combination, could be identified for two regionally-distinct beach management issues. These preliminary frameworks illustrate how relatively new and useful approaches to both environmental assessment and policy-formulation can be employed in region-specific manners. They are not meant to represent definitive results. The structure of the Florida example and the Antillean policy analysis were designed to catalyze regional experts to systematically refine these initial frameworks into revised analytic structures for direct application in both regions. Although both examples employed aspects of CERA techniques for environmental assessment and AHP techniques for policy analysis, differences existed as well. For example, unlike Florida, the Antillean AHP structure included criteria in addition to environmental issues. The inclusion of such criteria could have been switched based on the specific information available and the proximal management needs. The point is that both analytical approaches are flexible within themselves and can be used independently, in combination with each other, or in combination with other environmental assessment or decision support methods. The possibilities for differing integrations are as varied as the breadth of problems and management perspectives. In the wider Caribbean Basin, the potential for innovative and powerful applications of such tools is substantial, yet untouched.

The Need for a Cumulative Perspective

A wide variety of literature (Odum, 1982; Spaling and Smit, 1993; Hilton, 1994) has suggested that current EIA approaches aren't fulfilling their comprehensive purposes. It is commonly known that EIA's are perceived by some development interests and governments as simply "the cost of doing business", despite the best intentions of the preparers. Often in EIA documents, conclusions of no long-term effects are reached after high-quality literature reviews that identify a variety of: 1) *negative impacts* or 2) *information voids*. Such contrasts between analyses and conclusions are distributed among many EIA's associated with beach dredging projects. Perhaps such contradictions can be warranted in the presence of thorough and up-front mitigation, but the points here are simple:

(1) for dozens of biological variables among hundreds of species - we do not yet know if cumulative population-scale effects are benign, particularly with large-scale dredging.
(2) administrative momentum can build from one EIA to the next - reinforcing an optimistic hypothesis with incomplete data as an acceptable conclusion, and eventually, a "fact" - (often with little new impact data between the successive EIA's).

Collectively, these problems, and others (e.g., Spaling and Smit, 1993), undercut the scientific value of environmental impact assessments. When cumulative effects are possible but unevaluated, this should be overtly stated, with some detail paid to worst-case, as well as best-case scenarios. Too often, no or little cumulative consideration is given, or it is obfuscated by euphemistic predictions. Repetitive reviews of limited databases are fostered, and in time, codified as dogma. Ultimately, resources can be diverted from doing the detailed field or lab research needed to fill the key information voids. Recently, a variety of methodological approaches for incorporating cumulative effects into EIA's have been developed (e.g., Cocklin *et al.*, 1992; Vestal and Rieser, 1995; Dixon and Montz, 1995). Given the potential for long term biological consequences in Florida and the Antilles, future EIA's from both regions should include detailed assessment of cumulative effects.

ACKNOWLEDGEMENTS

The support of the Elizabeth Ordway Dunn Foundation and Coastal Research & Education have been essential. Additional support was provided by the Weeden Family Foundation. In Florida, a variety of individuals contributed to this project. These include J. Ault, A. Gonzalez, D. Snyder, H. Wanless, A. Stone, B. Schoppaul and M. Ridler. In the Antilles, the input of experts from a variety of nations is acknowledged. These include A. Handler, B. Lettsome, L. Potter, A. Suzyumov, and E. Towle. The technical and logistic assistance of G. Cambers is particularly appreciated.

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C. THE MANAGEMENT OF TRADITIONAL AND SOCIO-CULTURAL BEACH RESOURCES

MODERN VERSUS TRADITIONAL USES IN THE COASTAL ZONE OF ANTIGUA AND BARBUDA : A CASE FOR THE ESTABLISHMENT OF PERMANENT LANDING SITES, THE LIGNUMVITAE BAY EXPERIENCE

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ABSTRACT

Lignumvitae Bay is located on the southwest coast of Antigua. The white sandy beaches of Mosquito Cove and Jolly Beach are two of the beaches located along this three mile stretch of coast. Adjacent to the coast was the Jolly Hill Salt Pond and mangrove which occupied over 50 acres. Traditionally, the fishermen from the nearby communities used this area as landing sites. Conflict came as the fishermen were displaced by the establishment of the Jolly Beach Hotel, and later the Jolly Harbour complex. This type of conflict has become very common around the coastal areas of Antigua and Barbuda, where hoteliers are seeking private coastal areas and in doing so are encroaching on sites traditionally used by fishermen. This paper traces the evolution of the problem and develops a formula for resolution of such conflicts.

BACKGROUND

Antigua and Barbuda has numerous wetland sites with a combined area of nearly 5,000 hectares. These wetlands are usually a combination of salt ponds and mangrove swamps, with strips of white sandy beaches, which makes the area particularly attractive for tourism development. The land adjacent to these beaches is often too narrow to accommodate development and in-filling of parts of the entire wetland is practiced. Until recently these areas were often seen as wasteland, only to be used as garbage dumps. These areas were leased or sold to developers for very low prices. For the developers, it was an opportunity to transform cheap wetlands into condominium/marina projects for substantial returns. For the government, it was an opportunity to transform useless lands into jobs and additional revenue.

However, these areas were also used as fish landing sites. Fishermen would moor their boats in the calm sheltered bays adjacent to these wetlands. The bays, with their extensive seagrass beds and offshore reefs, were very productive, and fishermen had only to travel very short distances offshore for a good catch.

LIGNUMVITAE BAY EXPERIENCE

Lignumvitae Bay is an example of one such area. The bay is located on the southwest coast of Antigua. The white sandy beaches of Mosquito Cove and Jolly Beach are two of the beaches within the bay. Jolly Beach is more than a mile long and is one of the longest beaches on the island. The 1968 DOS map of the area shows the following significant features : to the northwest of the bay is the Jolly Hill Salt Pond and mangrove, an area of approximately 50 acres. Human settlement in the area is evidenced by the 78 room Jolly Beach Hotel and the villages of Bolans and Jennings.

Fisheries and human occupation have long been significant in this area. In fact, evidence of the shell fish middens site now occupied by Jolly Castle Hotel, has been identified as one of the oldest human settlements in the Eastern Caribbean, dating back to pre-Columbian times.

During the colonial era, up to the 1950's, the area was used variously for coconut cultivation, recreation, bird hunting, crabbing and mangrove wood harvesting. The Jolly Beach Hotel (now renamed Club Antigua) was built in 1962 with 78 rooms. This introduced tourism in the area.

During this period, fishermen had been using Jolly Beach and Mosquito Cove to land their catch, the fishermen opting for the bay closest to their homes.

It was not until the 1980's that conflicting uses began to be a problem in the Jolly Beach area. Between 1977 and 1979, Jolly Beach Hotel expanded to 470 rooms and became the largest hotel in the Eastern Caribbean. The hotel now sits on 40 acres of land and offers all inclusive service. In 1991 work began on the Jolly Harbour Marina, the Jolly Hill Salt Pond was dredged and infilled and Mosquito Cove was used to stockpile sand resulting from the dredging.

As the construction phase came to an end and the condominiums were ready to be leased or sold, the presence of the fishermen was unwelcome. The management complained about not being able to sell the condominiums in the area the fishermen occupied, as the fishermen kept the area dirty with their fish traps, nets, fish boxes and conch shells. The number and the size of the boats increased. There were problems with the security, as the fishermen wanted to enter the complex between 3 and 5 a.m. in the morning, taking hordes of family members with them.

The fishermen, on the other hand, also had their complaints. They resented the idea of having to be searched every time they entered and left the compound, which might be several times in any one day. At times they were denied entry in the early hours of the morning. Family members accompanying them were not allowed entry, and vehicles had to be left at the gate, while the fishermen toted their gear and other equipment to the area where the boats were moored. Even the fishermen's donkeys became a problem. The fishermen were also not able to haul their vessels up for repairs because of the nature of the bulkhead. The fishermen also indicated that they did not want to be associated with the drug activities they had seen in the complex.

Signs were placed giving the fishermen a deadline to vacate the Jolly Harbour complex. At one point the management threatened to bring an injunction against the fishermen if they were not out by the deadline set.

The fishermen insisted they could not move until their original landing site at Mosquito Cove was restored. The public road once leading to the area was badly degraded and the siltation of the bay prevented even the smaller vessels from entering without considerable difficulty. The landing site was therefore not accessible either from the landward or seaward side.

Several attempts were made by the government and the fishermen themselves to bring both parties together to resolve this issue. The fishermen are insisting that the road be repaired and a channel and turning basin dredged. The Jolly Harbour management is only willing to construct a jetty to accommodate the fishermen. The fishermen are, however, contending, that if the landing site is not accessible, the jetty is of no use. The problem is still not resolved.

SOLUTION TO THE PROBLEM

Conflicts between traditional and modern coastal zone users are becoming quite common in Antigua and Barbuda. The problem exists not only for fishermen, but also for recreational beach users when they are denied access by fences and security guards; for small business persons such as vendors, water sports operators, plying their trade to the tourists of these all inclusive resorts. Other problems occur, such as erosion when the development takes place too close to the shoreline, pollution from sewage outfalls and the destruction of marine resources which affects both residents and tourists.

General Solutions

1. A comprehensive coastal zone management programme aimed at providing guidance for specific development and management activities.

2. Mandatory environmental impact assessment (EIA) for all major development projects in the coastal zone. The EIAs should include public participation.

Specific Solutions to the Lignumvitae Bay Problems

1. The Fisheries Division should identify and establish permanent landing sites for fishermen. The areas selected should take into consideration the future development plans for the area.

2. When these landing sites are identified, these lands should be acquired for public use.

3. An educational campaign should be conducted, aimed at fishermen, developers and other coastal zone users, to sensitize them to the fact that coastal zone uses are not always mutually exclusive and that benefits can be gained from co-existence.

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TRADITIONAL AND SOCIO-CULTURAL BEACH MANAGEMENT ISSUES: A REGIONAL ASSESSMENT

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ABSTRACT

This paper presents the results of a questionnaire survey which focused on six major subject areas : beach maintenance, water safety for beachgoers, public access to beaches, conflicts between various beach user groups, noise and other issues. The respondents were mainly from government agencies in the islands of: Anguilla, Antigua-Barbuda, British Virgin Islands, Dominica, Grenada, Montserrat, Nevis, St. Kitts, St. Lucia, St. Vincent & the Grenadines, Turks and Caicos Islands. Personal interviews as well as a mailing approach were utilized. Major issues identified were : the lack, and in some islands complete absence, of public beach facilities including parking, toilets and changing areas; conflicts between different user groups; and a lack of public access to the beaches, especially vehicular access. Sustainable management of the region's beaches will only result when governments, together with local communities, NGOs and the public are fully involved in the search for, and implementation of solutions. In the short term it is likely that beach management will continue to be approached on a piecemeal basis.

INTRODUCTION

The small islands of the Eastern Caribbean are working towards the goal of integrated coastal management, however experience has shown that this often takes decades to achieve (Cambers, 1993, 1996). Within the context of UNESCO's Coasts and Small Islands (CSI) programme, COSALC (Coast and Beach Stability in the Lesser Antilles) is helping these islands work towards that goal by focusing on one particular problem - mitigating the impacts of coastline instability through integrated planning and management. The overall objective of COSALC is to develop in-country capabilities so that the island states can measure, assess and manage their own beach resources within an overall framework of integrated coastal management.

Much of COSALC's work to date has concentrated on the management of the physical aspects of beach erosion. However, in keeping with the overall goals of UNESCO's CSI project, it is especially timely to consider the cultural and socio-economic dimensions of beach management including traditional management practices.

This paper addresses the broader context of beach management and provides an overall assessment of various traditional and socio-cultural issues as they relate to beaches in these small islands. The paper describes and discusses the results of a questionnaire survey and provides some directions for future work.

METHODOLOGY

The major functions of beaches are as follows :

- recreational resource,
- part of the tourism product,
- fish landing sites,
- protection of coastal infrastructure,
- source of fine aggregate,
- habitat for nesting sea turtles and other plants and animals.

The protective and mining uses of beaches are being addressed within the COSALC project through the management of the physical aspects of beach erosion. A questionnaire was designed which focused on the other uses of beaches, the main subject areas addressed were: :

- beach maintenance,
- water safety for beachgoers,
- public access to beaches,
- conflicts between various beach user groups,
- noise,
- other issues.

A combination of direct interviews and mailed questionnaires was adopted. Responses were received from the eleven islands belonging to COSALC: Anguilla, Antigua and Barbuda, British Virgin Islands (B.V.I.), Dominica, Grenada, Montserrat, Nevis, St. Kitts, St. Lucia, St. Vincent & the Grenadines, Turks & Caicos Islands. Most of the respondents were from government departments, although in Nevis a non government organization (NGO) also participated in the survey. In this first assessment no attempt has been made to survey beach users. This would be the focus of a wider follow-up survey.

RESULTS

Beach Maintenance

As regards beach cleaning, certain popular beaches were cleaned on a regular basis by government agencies in six countries - B.V.I., Grenada, St. Kitts, St. Lucia, St. Vincent & the Grenadines and the Turks & Caicos Islands. In Antigua and Barbuda, beaches are cleaned on request. Beach cleaning activities are usually the responsibility of Health, Forestry or

Environmental agencies. In the remaining four countries - Anguilla, Dominica, Montserrat and Nevis - there are no regular government sponsored beach cleaning activities.

In the area of beach cleaning, the B.V.I was the most advanced country. Here eleven beaches are cleaned regularly, some on a daily, some on a weekly basis. In most islands some hotels and private establishments clean the beaches in front of their properties. One problem raised in St. Kitts, which also relates to other islands, is the question of what to clean ? For instance, in relation to seagrass, some people prefer beaches left in the natural state and would therefore leave the seagrass on the sand, while others prefer bare sand beaches and wish to see the seagrass cleared up and removed. In the latter case this would have to be an almost daily exercise at some beaches.

Garbage is collected from the most popular and accessible beaches in all the islands on an intermittent or in some cases semi-regular basis. In all the islands, non government organizations (NGOs) conduct beach clean-ups on an occasional basis. NGOs include Rotary, Lions, National Trusts and other national groups. In some islands local communities may get involved in beach clean-ups.

All the islands, with the exception of Antigua and Barbuda and Montserrat, take part in the annual International Beach Clean-up activity which is organized by the Center for Marine Conservation in Washington D.C. This international event combines beach clean-ups with a scientific collection of data relating to the materials collected. Analysis of the data provides information on the amounts and types of trash, its sources and distribution, and the risks and hazards it poses for the marine environment. The information is being used to bring about positive change at the local, national and international level.

Tree planting/revegetation projects have been conducted on the beaches in some islands, namely Anguilla, B.V.I., Dominica, Montserrat, St. Lucia and St. Vincent & the Grenadines. Usually this has been a partnership between government agencies, often the forestry departments, and local NGOs, communities and service organizations. Hotels and private owners often landscape the beach in front of their properties sometimes using exotic species.

Conflicts sometimes occur regarding the types of vegetation to use for planting. For instance from a tourism standpoint, palm trees are typically associated with tropical beaches. However, from an erosion standpoint, palm trees have very shallow roots and are easily undermined during periods of high wave activity. Alternatives such as almond and sea grape trees are deeper rooting and offer more resistance to wave activity. Trees such as manchineels have very deep rooting systems, but these trees are often feared by operators of tourism facilities because of their poisonous fruits and sap. Nevertheless, tourism and manchineel trees can co-exist through awareness and education programmes.

Public beach facilities, which include parking, changing rooms, showers and toilets, are scarce in the islands. Only in six countries are such facilities maintained : B.V.I., Dominica, Grenada, Montserrat, St. Vincent & the Grenadines and the Turks & Caicos Islands. Usually such facilities only exist at two or three beaches in each of these countries. Nevertheless all the islands recognize the need for such facilities. With existing facilities, maintenance is a major problem. In Antigua and Barbuda beach facilities used to exist at Fort James but they have fallen into disrepair and have been abandoned. In Grenada, recently constructed facilities at Camerhogne Park, Grand Anse, are poorly maintained and may follow the same pattern as those at Fort James in the future.

Water Safety for Beachgoers

The number of drowning incidents ranged from none in Montserrat and Nevis, to two to three per year in Antigua and Barbuda, to five incidents in 1995 in the B.V.I. These deaths included local residents and tourists.

Some islands, B.V.I. and St. Kitts, are considering putting up warning notices at certain beaches to advise bathers of potential risks. However, in the B.V.I. such notices were put up at several beaches in 1989, but have since been washed away or vandalised.

None of the islands had a system of trained lifeguards and indeed it was not perceived that there was a need for lifeguards. The two exceptions were the B.V.I. and St. Lucia. In the B.V.I. consideration had been given to the idea of establishing a lifeguard system, although the concept had not been implemented mainly because of the financial cost involved. In St. Lucia, lifeguards are employed by the beachfront hotels in the north of the island.

In St. Vincent & the Grenadines, where most of the drownings involve local residents and take place on public holidays, a system has been implemented whereby the Coastguard patrol the most popular beaches on public holidays thereby providing some means of rescue in the event of a water safety incident.

Beach Access

Generally the lack of beach access is viewed as a serious problem. Five countries - Anguilla, Antigua and Barbuda, B.V.I., Grenada and the Turks & Caicos Islands - viewed this as a major problem. In Dominica, St. Lucia and St. Vincent & the Grenadines, this was viewed as a serious, but localized problem.

Only in three countries - Montserrat, Nevis and St. Kitts - was beach access not viewed as a serious problem. In St. Kitts and Nevis, the National Conservation and Environmental Protection Act (1987) states that there must be a public access at every beach. While in Montserrat, the relatively low level of hotel development behind the beaches does not impede public access to the beaches.

In all the countries who responded to the questionnaire the provision of public access to the beaches is considered in all new coastal development applications. Thus future coastal developments should not add to the existing problems. Nevertheless these existing problems are considerable. In Antigua and Barbuda, a country heavily dependent on the tourism industry, public access was considered to be a major problem at almost every developed beach.

Public access problems are most severe at those beaches which have been developed for tourism. Often the public access, if it exists, may be located in an inconvenient place. For instance at Jolly Beach in Antigua, the public access is for pedestrians only and is located at the southern end of the beach where it runs through a swamp. In almost every island, the lack of vehicular access and parking was identified as a major problem. Many island residents who visit the beach come from a considerable distance and they need to bring their cars.

Another problem that was raised in St. Kitts and St. Lucia relates to all inclusive hotels. These establishments may wish to restrict all public access to the beach and therefore their facilities.

Perceptions about land and beach ownership vary from island to island. For instance in the Turks & Caicos Islands some beachfront landowners perceive that their ownership extends to the beach in front of their property. They therefore regard members of the public trying to access the beach adjacent to their properties as trespassers. In the B.V.I. where some small islands may be completely owned by one person, access to the island's beach from the sea may be regarded as trespassing by the owner.

In some islands, sea defences such as walls and revetments may project onto the beach itself. These may in turn impede access along the beach. Examples can be seen on the north coast of Providenciales in the Turks & Caicos Islands, at Dickenson Bay In Antigua and on the northwest coast of St. Lucia.

In other islands, private property fences may actually be extended across the beach into the water, again impeding access along the beach. Examples may be seen at Morris Bay and Mamora Bay in Antigua. Since all beaches in the islands are public property this practice is obviously illegal, yet due to inadequate legislation and often a lack of enforcement, it may take considerable time and effort to get such structures taken down. This was the case at Mahoe Bay in Virgin Gorda, where a property owner extended his fence into the sea in 1990, supposedly to prevent cows from trampling his garden. It took many months, many site visits and considerable pressure to get the fence removed.

Other problems may exist at some very popular beach sites which are also national parks. The Baths in Virgin Gorda, B.V.I., is a case in point. Here a small beach is surrounded by huge granite boulders creating a wonderland of caves and rock pools. Access is available from the land and the sea, but the very size of the area means that at some time in the future it may be necessary to restrict access to control the numbers of people visiting the site.

User Conflicts

In the questionnaire, jet skis were identified as a specific conflict and were the subject of a particular question. The respondents were then asked to identify other user conflicts.

The importance of the jet ski problem varied from island to island and depended on the legal status of jet skis. Only in four islands - Antigua and Barbuda, Nevis, St. Lucia and the Turks & Caicos Islands - were jet skis considered a serious problem. The noise caused by the machines and the fact that they were incompatible with low paced tourism objectives were the main reasons cited. Safety, for the users and for other beachgoers, was another concern, particularly since jet skis are often hired out to persons with no experience. A recent (1996) jet ski accident in Nevis had acted as a catalyst for government to review their beach management policy.

In the remaining seven islands - Anguilla, B.V.I., Dominica, Grenada, Montserrat, St. Kitts and St. Vincent & the Grenadines - it was generally considered that there were too few jet skis to constitute a problem. In Anguilla and the B.V.I., it is illegal to import jet skis, thus in these islands, their impact is minimal.

All the islands, with the exception of Dominica and St. Vincent & the Grenadines, identified conflicts between various user groups as a serious problem. The types of conflicts fell into four main groups:

(a) Conflicts between swimmers - snorkelers - divers on the one hand, and speed boats - dinghies - jet skis on the other hand. The main point at issue was safety, particularly for the individuals in the water. In several islands, partial solutions had been found at the more popular beaches by using buoyed swimming areas, where no boats were allowed. However, this solution can only be employed at selected beaches. In addition, problems may arise with the maintenance and enforcement of such areas. An example was seen at Cane Garden Bay in the B.V.I. This is a very popular yacht anchorage as well as a bathing beach. A buoyed swimming area was demarcated by a local NGO and worked well for a short time. However, buoys need maintenance and no one had budgeted for this cost, neither the NGO or the relevant government agency. Furthermore when yachts and their tenders from neighbouring islands visited the bay, the demarcated area was ignored and there was no one to enforce the policy except for some irate swimmers. This example perhaps speaks clearly of the need for a beach management policy.

(b) Another area of conflict found in several islands was between fishermen and divers over the use of the reefs. This was essentially a resource use conflict. For instance in Antigua-Barbuda divers claimed that fishermen were setting their pots actually on top of the reef crest. In turn fishermen were claiming that divers were cutting their pots free.

(c) Fishermen were also identified in another area of conflict, this time with new developments associated with the tourism industry. Fishermen were having to move from their traditional landing areas because of new tourist developments. Several examples were cited in Antigua such as at Emerald Cove, Jolly Beach and Carlisle Bay; examples also exist in other islands such as the B.V.I., where in St. Thomas Bay, Virgin Gorda, fishermen have to use the marina to moor their boats because of the loss of their traditional landing site.

(d) The fourth main area of conflict was cited in most islands who responded and relates also to the issue of beach access. Traditionally island residents visit their beaches, park their cars behind the beach and relax under the grape trees or other vegetation behind the beach. With so many beaches becoming developed for tourism, the beachfront land is becoming developed with hotels and private gardens. So the only really public area at these developed beaches is the strip of sand between the development and the sea. This area is not only hot, but some residents feel uncomfortable here, as if they are in someone else's backyard. In effect this privatization of the beachfront area may result in residents abandoning certain beaches altogether for their relaxation and recreation.

Noise

In eight of the eleven islands, noise was identified as a relatively minor and occasional problem in relation to beaches. Excessive noise was often linked to large beach parties which were usually infrequent events - limited to certain bank holidays. It was usually local residents or hotels in the area who complained about the noise generated by these events. Noise from local beach bars was identified as a nuisance in Antigua and Nevis.

In two islands, Anguilla and B.V.I., noise abatement ordinances have recently been passed. In general noise was viewed as a localized, infrequent problem, limited to one or two particular beaches on an island and not a major issue.

Other Issues

The other issues identified included personal safety, dogs and horses on the beach, illegal groynes, squatting on beaches, garbage and sewage disposal, a lack of clear definitions and understanding of public and private domain, and a need for coastal development setbacks.

DISCUSSION

None of the islands surveyed, with the possible exception of Nevis, have an overall beach management policy. Management, where it exists, is fragmented among different agencies. While many problems are known to exist, they are largely ignored until they reach crisis proportions.

This was borne out in Nevis, where a jet ski accident acted as a catalyst for the government to review their policy as regards the management of beaches.

The results of the questionnaire show the need for a beach management policy covering many different issues in each country. Obviously many issues overlap with other geographical sectors of the coastal zone. However, beaches are so heavily used by residents and tourists alike, as well as being vital to most islands' economies, that they merit priority treatment on an immediate basis.

Figure 1 shows a bar graph with a summary of the results. A lack of public beach facilities was identified as a problem in every island. With the few beach facilities that do exist, a lack of maintenance was cited as a major problem. Conflicts between different user groups was the second issue most often identified in the responses. The third most important area was a lack of public access to the beaches. Developments which resulted in the privatization of beachfront land often resulted in local residents abandoning traditionally popular beaches in favour of other beaches. While alternative undeveloped beaches still exist, this issue may not be of major concern. However, since tourism is the lifeblood of the region, it is likely that more and more beachfront land will be developed resulting in fewer traditional sites for recreation and relaxation of island residents.

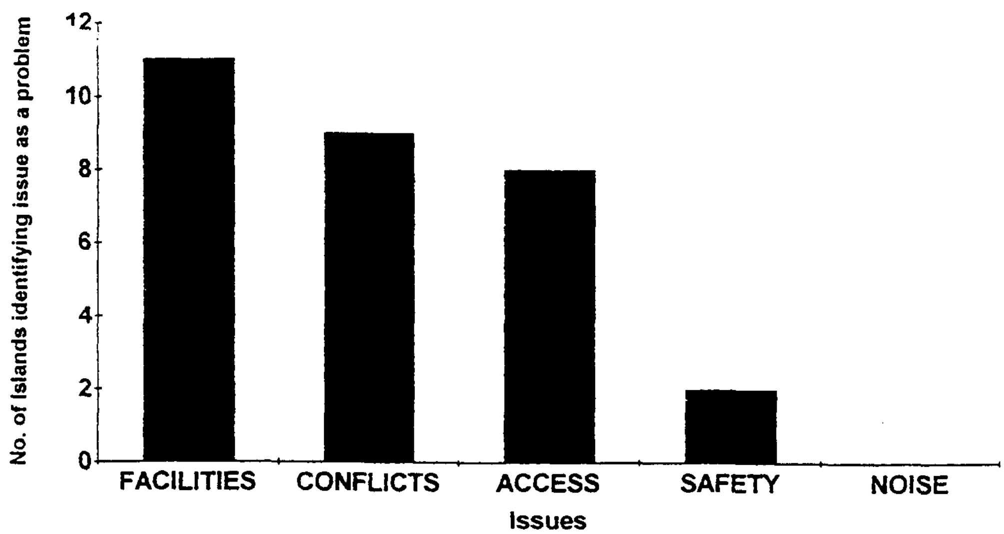

Figure 1 Summary of the Survey Results

The questionnaire results showed that the problems were most severe in those islands which were most developed for tourism, particularly Antigua and Barbuda, the B.V.I. and the northwest coast of St. Lucia. Similar problems also existed in the other islands, but they were generally less widespread.

Several worthwhile efforts have been started in the islands to try and manage some of these problems on an individual and localized basis. Some of these efforts have involved partnerships between NGOs, governments and communities. But in almost all cases the projects have been poorly planned lacking adequate provision for maintenance and enforcement.

The problem of enforcement is one met throughout the entire field of integrated coastal management in the islands. All too often the laws exist, but are not enforced. Enforcement cannot be laid entirely on the shoulders of the police personnel in each country. The police already have a full load to carry. We must look for more innovative ways, using our local communities and special interest groups to help enforce existing legislation. For instance, in the B.V.I., a surveillance and enforcement committee has recently been established. This includes all enforcement agencies (Conservation & Fisheries, Customs, Immigration as well as Police) with the overall goal to share resources and work together. With some aspects of beach management, local communities and the general public need to be empowered with the necessary information so they can become custodians of their own resources.

With dwindling resources and decreasing budgets, we must look for sustainable and innovative ways to manage our beaches. Systems of management that exist in other parts of the world may not fit out local situations or may be too expensive to implement. To take but one example - drownings occur in most islands every year, but few islands have considered installing a system of lifeguards, as has been done in Barbados for instance. The cost factor may well be prohibitive in the smaller islands of the Eastern Caribbean. Thus we must look for ways to fully utilize our local resources, as was done in St. Vincent & the Grenadines with the Coastguard patrolling popular beaches on public holidays. Programmes which teach school children swimming skills are another way in which drowning deaths can be reduced as well as enhancing children's lifestyles.

We need to apply the principles of integrated coastal management (ICM) in the management of beach resources. Key issues that should be considered are the involvement of all interested parties, public awareness and education, legislation and enforcement. Beach management problems will not be solved overnight, and indeed it is an ongoing process, for as problems are solved others arise. However, there is a wealth of experience within the region, relating to these problems and their solutions. We need to learn from the failures as well as the success stories.

RECOMMENDATIONS

This paper represents a first assessment of the many and varied problems involved in beach management in the smaller Eastern Caribbean Islands mainly as viewed from a government perspective. Beaches are a vital part of our islands' heritage and should be managed as such. However, the design and implementation of policies to manage our beaches has to be a long term objective given the existing human and financial resources available. In addition many of the presently existing pressures on beaches are new - they never existed in the past.

The first step is to recognize these pressures as problems, then to develop solutions within the context of a beach management policy. Physical planning and environmental agencies must liaise with tourism and health agencies and others to solve beach management problems in an effective manner. Communities, NGOs and private citizens should also be active participants in these initiatives.

There is a need for well defined ICM legislation. Draft harmonized ICM legislation already exists for the OECS countries which provides a starting point from which to work. Clear definitions of some of the "grey" areas relating to beaches such as public and private ownership, jurisdiction etc. must be included in this legislation.

There is a wealth of information in each country relating to beach management. This usually exists in the experiences of individuals, rarely is it documented in published or even "grey" literature. There is a need to exchange this information and experience through meetings and publication of case studies as a form of technical cooperation between developing countries.

CONCLUDING REMARKS

The questionnaire response from the Turks & Caicos Islands included a statement that perhaps summarizes very aptly the region's attitude to its beaches: "Despite their value to the tourism industry, beaches are given very low priority in government". This can be seen in all matters relating to beaches, from erosion to access, from mining to ownership. Beaches are an important part of our islands' natural, traditional and cultural heritage, they also play a key economic role. The key to sustainable management of our beach resources lies in conserving our islands' heritage while at the same time developing and enhancing the economic potential of our beaches.

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COMMUNITY BASED APPROACHES TO BEACH MANAGEMENT IN ST. LUCIA

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ABSTRACT

Problems facing beaches in St. Lucia, such as erosion, beach sand mining, shoreline alterations and pollution are discussed within an Island Systems Management Approach. Since there is no clear authority in St. Lucia for the management of the use of beaches, a community participation approach is discussed. It is proposed to establish local management authorities (L.M.A.'s) which will consist of government agencies, community groups, schools, non government organizations, hotels and the private sector to provide for solutions to some of the problems facing beaches.

INTRODUCTION

Beaches have long been the focus of social and cultural pastime in the small islands of the Caribbean. Our fascination with them at that time was predicated not on utility, but on the revered deification of the sea as the god of plenty, with beaches representing an important communal link so often romanticized in West Indian Literature. Beaches were very much a part of every day life with little if any consideration given to possible threats to that system. Seasonal fluctuations were taken in stride almost as part of the fluctuations in the lives of those communities to whom the beach was a vital commodity.

Development so often characterized by infrastructural growth created a shift in focus from socio-cultural and recreational to industrial utilization. Beaches were now seen as indiminishable sources of construction aggregate, supporting the growth in that industry. Residents, manufacturers and the hotel industry have benefitted tremendously from this resource sitting virtually at the doorstep of the construction process. The dilemma which results today is that the very resource which serves as the basis of recreation and tourism is in danger of being destroyed by those very elements on which these depend.

The recognition of the demise of beaches in St.Lucia led to a voluntary decision taken by the hotel industry not to use local sand for the construction of hotels but rather to import sand for such purposes. This was followed by a government decision to restrict the mining of sand to a very few areas, and in large part to support the construction industry by promoting pumice as an alternate to sand as a construction aggregate. Today all sand for construction is imported from Martinique, the Republic of Trinidad and Tobago as well as Guyana. Illegal sand mining still continues despite the controls established to ensure that this does not take place.

The control of beach sand mining is a step in the right direction but probably not soon enough. Sediment budgets have been affected to the point where most beaches have been reduced to mere slivers of shoreline where in the past they have been prominent features. Indiscriminate sand mining has not been the only factor affecting beaches today. Inland anthropogenic activities of all kinds ranging from agriculture, deforestation, building construction, river retraining as well as the construction of dams all affect the sediment budget particularly where beaches are dependent on terrigenous supplies.

One of the main issues concerning beaches as well as other natural resources is the inability to place an economic value on them. Traditional economics simply does not cater to the valuation of natural resources, thus the development of the pioneering field of resource economics which is still a long way off from perfecting the system of resource valuation. In almost all instances the value of natural resources is normally weighed against its conversion value. This in simple terms means that natural capital is not seen to have significant economic potential when compared to that of other development, particularly that of tourism. Income generating activities with a strong employment component usually take precedence over sustainable resource management activities. Industries such as tourism appear much more attractive to the administrator because of the high employment potential, but the concern for shore habitats has not featured well in the traditional planning process in small islands.

The management of beaches must not be seen in isolation of the management of other natural systems on small islands. Each island must be seen as a heterogeneous discrete entity, made up of an assemblage of diverse subaerial and subaqueous ecosystems in upland, littoral, sublittoral, and outer-shelf zones (Towle, 1985) all interacting with each other. The interdependent linkages of all these systems are particularly important once it is understood that any impact on one will have repercussions on others. The size of these systems do not readily conform to geographical, political or other ecological boundaries, and as a result, growth, development and the physical environment are all interlinked in a matrix which creates multiple feedback loops. Management must therefore consider the entire range of issues from resource protection to sustainable infrastructural and economic development across the entire range of ecosystems.

IMPACTS OF ANTHROPOGENIC ACTIVITIES

In order to understand how beaches are affected by anthropogenic activities, it is necessary to understand first where beach sand comes from. However this section does not attempt to examine all possible sources but only to highlight a few for the purposes of this discussion. Sediment supplies are from two sources; terrigenous (land based) and marine (biological and from offshore deposits - sinks) (Pilkey *et al*,1989). Erosion of inland areas and the subsequent downriver transport to shorelines provide sediment to some beaches particularly where these are usually associated with river systems. In some instances this is the main source of beach sediment and any interference with the natural flow is likely to create negative impacts to the detriment of the beach. Marine sources are quite varied and range from the production of grains by the mechanical action of frictional forces on coralline structures or from many marine organisms which either through their death or through the interaction with other organisms produce grain size particles.

Beaches tend to be the result of a combination of these factors, the extent to which they all contribute varying from system to system. Any interference with one of the main contributors will alter the sediment budget with the resultant loss of the beach. The rate of loss will depend on the gravity of the interference. Sand mining in itself has been proven to have the greatest impact in the Organization of Eastern Caribbean States (OECS), in many instances resulting in the total loss of the beach. The absence of viable alternative sources of construction aggregate served to encourage mining with little if any consideration to the detrimental effects. Even today some governments are not totally willing to consider alternatives, a must if the tide of degradation is to be stemmed.

Shoreline alterations in the form of groynes, seawalls, causeways, jetties, ports, marinas and revetments affect the ocean dynamics which dictate the character of the particular system. The shift in balance can have a positive effect if this is not at the expense of neighboring systems, or a negative effect as experiences have shown in the OECS-subregion. The alteration to shorelines are usually made to facilitate tourism development. The growth in that industry has been accompanied by an increase in water-based activities some of which such as the operations of craft powered by outboard engines and fueled by a petrol-oil mixture lead to the contamination of sensitive areas.

The absence of proper land-use policies and adequate legislation encouraged the construction of hotels, seawalls and other structures on the active portion of beaches. Entire shorelines have been decimated as a result, a situation further compounded by the establishment of property protection structures that do nothing to mitigate the impact. It is very clear that if the tide of beach destruction is to be stemmed, immediate consideration must be given to the protection of these resources from destructive physical agents. However concerns for beach loss must extend to inland anthropogenic activities which cause harm to systems contributing to the sediment budget. Agricultural and industrial chemicals, untreated sewage, liquid discharges such as hypersaline and hyperthermal water from reverse osmosis and power plants are just a few of the other physical and chemical agents responsible for the indirect degradation of beaches.

Changes associated with global climate changes and the concurrent sea-level rise as a result of global warming must feature in the overall planning process for the management of use of shore areas prone to flooding from storm surge. In many instances we have built cities, towns and villages in these areas, many of which are now considered hazardous and require disaster mitigation measures to ensure the continued protection of life and property. The range of issues identified cannot be addressed only by sectoral approaches. It is through a multi-sectoral interdisciplinary approach such as that identified in the OECS-NRMU "Islands System Management Plan" can the multitude of issues be successfully addressed. However in considering the holistic approach, the role of community involvement in the management of the use of specific ecosystems must be granted credence.

THE COMMUNITY-BASED APPROACH

Community based approaches to the management of the use of resources is not a new concept and despite its novelty has had applications in various parts of the region. Experiences with community involvement in fuelwood production in mangroves is highlighted in some literature (Bossi and Cintron,1990; Panos Institute/CANARI, 1994, Renard, 1991; Smith and Berkes, 1993), which elucidate the value of that approach. The involvement of communities in the management of the use of natural resources is considered a necessity in order to ensure sustainable use. The sustainable development paradigm highlights community involvement as one of the key components for the success of the management of the use of natural resources. It is this principle in which the tenets of stewardship, empowerment and self-worth are enshrined and which forms the basis of the "*National Action Plan for the Management of Beaches and Mangals*" in St.Lucia.

Beach Management in St. Lucia

There is no clear authority in St.Lucia for the management of the use of beaches. Jurisdiction over certain activities falls under the auspices of agencies with none having complete control. The *Beach Protection Act* (No.2 of 1967) essentially allows the Ministry of Works control over mining activities and the transport of aggregate. This is only important in areas where beaches have the potential for or are being mined. This measure is not effective with illegal mining still occurring even in areas where this has been disallowed. The Beaches and Parks Commission restricts its operations to those beaches which are tagged recreational and have a definite touristic value. The range of management options is limited with greater emphasis placed on waste collection and disposal as well as vending. The Fisheries Act (No. 10 of 1984) allows for the declaration of beaches as marine reserves, but this caters only to those beaches with importance to marine organisms such as turtles for nesting purposes. It is clear that the system of management has to be revisited in order to ensure comprehensive management over all beaches, whether or not they have some recognized importance. The action program developed for beaches in St.Lucia was predicated on this premise, but received a jump start from the OECS-NRMU through its "Coastal Zone Management Program" presently funded through the German Technical Cooperation Program (GTZ).

Sustainable coastal development and effective beach management is achievable when the governance process responds and is accountable to the people who live with the results. Participation of people is invariably essential for successful management of natural resources.

Further to community participation, there needs to be the forging of partnerships among user groups and government management agencies.

This aspect of community participation promotes the integrated approach for an Island System Management Process that must be multi sectoral in nature. Essential to this process must be a feature of learning and adaptation that will contribute to the building of local capacity . Issues analysis and implementation of strategies and planning are dynamic processes requiring constant refinement as new information becomes available, experience accumulates and the political, economic and social context within which the programme operates changes. Methods must be formulated that allow for community involvement in addressing specific issues of coastal resources management such as beach management.

Under the Action Plan for the management of beaches and mangroves in St. Lucia, the government is in the process of establishing *Local Management Authorities* (L.M.A.'s). These will comprise of representatives from government agencies, community groups, schools, non-governmental organizations, hotels, service organizations and the private sector. Such a mechanism is expected to consolidate the idea of collaborative and participatory approaches to management, and further promote the involvement of communities in the identification and solution of environmental problems.

Beaches like other components of the coastal zone support a myriad of uses and activities. These uses are not necessarily compatible with each other or with the maintenance of the coastal ecosystem. As a result, conflict occurs among users. Such conflicts are often not adequately addressed by government policy and regulatory controls which have developed along sectoral lines. The *Local Management Authorities* represent one mechanism that could be used to resolve these conflicts so that agreed upon goals of beach management can be achieved and the legitimate but sometimes conflicting objectives of disparate interests can be accommodated. Effective Local Management Authorities must however be based on key stakeholder partnerships that will encourage improved management of beach resources.

For more effective management of beaches, there needs to be regular beach monitoring programmes that document changes in beach dynamics. One of the major problems in generating island wide beach data has been inadequate manpower. It is proposed that this shortcoming could be addressed through the involvement of schools or other community groups in the overall program, where each of these groups or organizations might have a vested interest in these systems. Such groups would thus form the basis for L.M.A.'s in those selected areas. L.M.A.'s will also form the basis of data collection, evaluation, the development of management plans and eventual management of the use of these systems. Such a mechanism by promoting volunteer public monitoring and community action programs also serves to increase public education and awareness and to involve all relevant sectors in the stewardship of beaches and the coastal environment in general.

The establishment of L.M.A.'s needs to be preceded by a comprehensive inventory of the status and economic importance of all beaches in the island. This enables the prioritization of areas which require immediate remedial attention. A phased approach to the establishment of these L.M.A.'s is thus recommended to effectively manage beaches of highest priority. It is expected that L.M.A.'s will form the basis for the development of special management zones that engage local residents, resource users and authorities in an open planning process to address the future use of coastal resources around the entire island. This is also expected to strengthen local capacity and establish a national commitment towards more effective management of beaches and other coastal resources.

The use of L.M.A.'s in essence allows for an inbuilt community participation component which is deemed necessary for the successful implementation of any management plan. The public involvement component should also be seen as incorporating the commercial sector in the program. This stresses the development of an attitude of stewardship, instilling in the general public the sense of responsibility towards the sustainable development of the natural resources of the island. In this process, a sense of ownership is also nurtured, a key ingredient to soliciting the full-time long term involvement of communities in the program.

There is a need to use an approach to issue analysis that considers the historical roots of the present and the long-term implications of trends in social and economic change. It is then necessary to formulate with those most directly affected, area-specific management plans that identify specific priorities for both conservation and development and attract the support of local communities and stakeholders. These area specific management initiatives must be incorporated into a broader framework of planning, decision making and implementation of actions in order to achieve the sustainable use of resources. This implies that integration and intersectoral collaboration is key to the process. The Islands Systems framework encapsulates these requirements through the formal institutionalization of this holistic process thus ensuring the successful operationalization of integrated resources management.

ISLANDS SYSTEMS MANAGEMENT

The management of beaches in St.Lucia is predicated on the "*Island System*" concept first described by Towle (1985) and from the philosophy of "*Island Systems Management (ISM)*" which in turn is developed from the former concept. The diminutive size of small islands means that development and the physical environment are closely related and interdependent. Management therefor must span the range of issues from protection to the environmentally sound exploitation of resources. Climate change and sea-level rise are also issues of grave concern and must also be considered in the management of development on shore areas.

Although tropical shore ecosystems have narrower tolerance limits to anthropogenic impacts than corresponding systems in other latitudes and are more susceptible to degradation, management cannot be focussed on shore areas and instead must consider the entire range of issues on small islands if sustainable use is to be achieved (Nichols and Chase, 1995). It is the assemblage of "systems" which characterizes most islands and on which the philosophy of Islands Systems Management (ISM) is hinged. Any small island in the sub-region can be seen as an intricate network of interactions complicated further by the human intervention on the environment. For all intents and purposes an island is essentially all coastal when consideration is given to the full range of seaward and landward influences of climate and anthropogenic activities.

Nichols and Chase describe ISM as "a multi-disciplinary, multi-sectoral, multi-facetted mechanism aimed at rationalizing the use of island resources and the achievement of goals of sustainable development". Chase (1994) adds that it is an adaptive strategy which addresses the issue of resource-use conflicts, and which provides the necessary policy orientation to control the impacts of human intervention on the environment. The process in itself is only workable if it is couched within an institutional and legal framework, coordinating the initiatives of all public and private sectors while ensuring the achievement of objectives through inter-agency collaboration.

Management of the use of resources can be effected through a **spatial** or an **issue** based approach. The spatial framework focuses on geographic features, such as watersheds, estuaries, river basins or valleys at the upper end of the size spectrum, or seagrass beds, coral reefs, mangals at the other end. This allows any authority to concentrate efforts on specific areas requiring attention. If management is to be effective in considering the full range of issues in any geographic area it must be multisectoral and multidisciplinary. This approach eliminates the need for sectoral, physical political or cultural boundaries which can only hinder the flexibility of the management authority. The issue based approach focusses on problem areas such as liquid or solid waste management, beach sand mining, shoreline alterations, erosion, public health and others. This allows for the concentration of efforts on specific areas requiring attention.

It is within this framework that the management of the use of beaches is couched. The multi-disciplinary approach allows for the involvement of the public and private sector, NGO's as well as the wider community. This collaborative approach is more likely to derive solutions to existing problems than the uni-sectoral approach which characterizes normal management.

CONCLUSION

Beaches are too important to the economic, social, cultural and physical well-being of tropical island communities to lose to the unbridled forces of development and environmental degradation. The drive to secure tourism as the number one revenue earner in most of the region has led governments to allowing the tourism entities almost exclusive use of beach areas to the point of exclusion of the local populace. This loss of recreational opportunity can have severe social impacts if this trend is allowed to continue. Although public access is to be provided as a condition of approval for the construction of hotels along beaches, in some instances this is not yet a legal requirement. The gradual erosion of access to beaches by locals by what is perceived to be a form of neo-colonialism and the diminishing recreational opportunities can create serious conflicts of use to the detriment of the economic stability of these islands.

Apart from these considerations the physical importance of beaches to the overall ecology of islands as well as the protection offered shorelines from the destructive forces of erosion, suggests that immediate measures must be taken if the integrity of beaches is to be maintained. Community-based approaches appear to be one of the more effective means of achieving solutions to the present impasse through the method of stakeholder involvement in all aspects of decision making, and in planning for future uses. This system has also to guide the approval process for hotel development and to help inform the political directorate on the most appropriate development strategies.

The Island Systems Management framework represents the first approach to multi-stakeholder involvement in its form in the decision-making, planning and implementation process of island resources management. It heralds the dawn of decentralization in a manner which aims to reduce government time and effort in management and the development of an empowered people realizing greater responsibilities as environmental stewards. The success of this approach is dependent on political will fostering greater partnerships between the people and their representatives. The approach further establishes a strong horizontal component in communication and decision-making that can only increase the efficiency of management of the use of island resources.

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ISSUES AFFECTING BEACHES IN GRENADA

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ABSTRACT

Grenada's beaches fulfill a number of functions, they provide fine aggregate for construction; they are important as an area for recreation and tourism; they also provide fish landing sites and areas for pulling up boats; finally they are an important animal habitat. Several conflicts between the various uses are discussed, the major conflict being between the use of the beach for sand mining and as a recreational resource. The need for well defined legislation and greater cooperation between the various coastal stakeholders is emphasized.

INTRODUCTION

The state of Grenada comprises three islands namely Grenada, Carriacou and Petite Martinique. Together they make up a land mass of 133 square miles. The principle industries are tourism, light manufacturing and agriculture, particularly the production of spices for which Grenada is famous and has earned the name "Isle of Spice".

With a population of approximately 100,000 persons and an increased number of tourists using our beaches, they are of vital importance to our well being and economy. As such, Grenada's beaches today are used by a growing number of persons for various activities which often clash and conflict.

In the past, management systems to control the use of our beaches were virtually non-existent, except regulations regarding the removal of sand from beaches and a setback policy for Grand Anse Beach. However, the growing economic importance of tourism, the growth in population, the need for housing and the recognition of the importance of fish landing sites, necessitate management decisions to preserve the beaches and reduce, if not eliminate, user conflict.

This paper presents an overview of some the issues affecting beaches in Grenada. It looks at the use of beaches, conflicts that arise from those uses, access, ownership and community involvement in management.

When we use the term beach, what do we really mean? Beaches are areas of loose unconsolidated material at the junction of the land and the sea. They may consist of sand, mud, stone, coral fragments or boulders. In this presentation we will be dealing with sand beaches, since these are the most important to Grenada.

USES OF GRENADA'S BEACHES

A Source of Fine Aggregate

Sand from the beaches of Grenada has been a major source of fine aggregate for applications in the construction industry. About 85% of fine aggregate used in the construction industry comes from our beaches.

Despite the passage of the Beach Protection Law (No. 67, 1979) there still is evidence of sand mining on many of Grenada's beaches. This mining was particularly widespread during the construction boom of the '80's, thus causing a narrowing and lowering of the mined beaches and seriously aggravating the coastal erosion already taking place. Most sea defences presently in place, protecting roads and other infrastructure along the beach, are a direct result of uncontrolled sand mining in the '80's.

Source of Recreation

Beaches in Grenada are traditionally a source of recreation for our people. It is usual that on weekends, public holidays and evenings, Grenadians head to the beach where they would engage in beach and water sports.

The beach can be said to be Grenada's favorite "liming spot". Many people meet and socialize on the beaches and conduct activities such as picnics. Recreation and other social activities on our beaches constitute the single use which can conflict with most other uses.

A Part of the Tourism Product

Tourism is of major importance to Grenada's economy. All year round, tourists can be found on our beaches. However, the peak season for tourism in Grenada is during the winter months in North America and Europe, when many tourists utilise our beaches.

Traditionally, the emphasis was on offering sun, sea and sand, but today, the tourism product has widened to include other recreational activities e.g. water and jet skiing.

An Aesthetically Pleasing Part of the Environment

Simply put, beaches are places of healing. One can relate to the feeling of well-being while relaxing on the beach. We know the effect a perfect sunset or beautiful sunrise has on us, or those of us who are so inclined, the romance of the moonlight and the beach. Beach users, particularly locals, enjoy an environment where there are trees on the beach. However, when these trees are replaced by development, a beach's appeal to island residents is diminished. When this happens local beach goers tend to abandon the developed beaches and instead frequent other undeveloped ones which provide inspiring views, cool breezes, and tranquilizing natural symphonies.

Provision of Fish Landing Sites, Habitats for Animals and Areas for Beaching Boats

It is not unusual, particularly on the western side of the island, to see the well co-ordinated movement of fisherfolk, as they use the beach to "pull seine" with their catch of fish. Other fisherfolk particularly those whose base are not served by a jetty land their catch on the beach nearest to their market, these beaches are therefore vital to the commercial fishery.

In addition, there are four (4) species of sea turtles using beaches in Grenada for nesting during the months of February through August, thus ensuring continuity of their species. Other animals too, use our beaches as their homes.

Other small sea craft operators use the beach as a place where they haul up their boats for repairs. The Carenage in St. George's, Grenada, though no longer a beach, got its name from the days when boat men would careen their boats there for repairs. Beaches also serve as a safe place for boats during storm weather or when there are no safe moorings available.

CONFLICTS IN THE USE OF BEACHES IN GRENADA

Possibly the biggest conflict arises between the need to remove sand from our beaches for use in construction of our homes and other infrastructural work and the need to have the beach for recreational purposes. When sand is mined particularly when it is done illegally, the beach looses its aesthetics. The beach becomes scarred with heavy vehicle tracks, while holes and mounds are left in the sand. Wild life who need the beach for their survival are put at risk as they cannot cope with what has now become a hostile landscape.

More recently a new type of conflict has arisen, between users of recreational crafts and bathers, divers and wildlife. For the most part, the problem is that crafts like jet skis are used by people with little or no experience in the operation of these crafts and can cause injury to other persons in the water. Even those who choose to remain on the sand are bombarded with noises from those crafts when they are operated too close to the shore. Water taxis plying back and forth between cruise ships and the beach also increase the risk of injury and conflict with swimmers, snorkelers and divers.

In 1993, the Grenada Board of Tourism and the Grenada Ports Authority sought to regulate a 300 ft. area of water immediately adjacent to the foreshore at Grand Anse. This did not meet with much success as the matter of enforcing the regulated zone was not efficiently carried out.

Fisherfolk also create conflict when remnants of the day's catch are either dumped in the sea or on the beach, causing an unpleasant smell and sight, or when they haul up boats for repairs and leave them for extended periods creating obstacles for other users.

Another conflict that arises particularly on Grand Anse beach, our most popular one, is between vendors and other beach users. These vendors display their wares, mostly clothes, on lines strung on trees growing on the beach, thus obstructing free passage. This problem should be solved with the completion of the EC$2.5 million vendors market at Grand Anse.

OWNERSHIP OF THE BEACH

It is often stated that "All beaches in Grenada are public property". This can be misleading because what is really public property is only the foreshore, that area that extends from the low water mark to the high water mark. Fortunately, our popular beaches are located on lands which are owned by Government and leased to developers except for the dry sand part. There are, however, other beaches which are located on private property, which are used by visitors and locals under the impression that all the beach is public property, but this amounts to a trespass on private property.

An example of how this matter can be addressed is in recent legislation adopted in St. Kitts Nevis, which states that the Crown (Government) owns the area extending twenty (20) meters beyond the high water mark. This type of legislation will protect most of the sand and allow adequate use of the area without trespass. Where there is no clear legislation, British Common Law is used to settle disputes and the following conditions have been upheld:-

1. Gains or losses in beach areas due to normal causes result in movement of beach boundaries. So if a beach accretes naturally, the land area of beachfront property increases; by the same token, on a beach that has eroded due to natural causes, beachfront property decreases in size.

2. A sudden change in the beach area resulting from a "non-natural" or human intervention, such as the construction of a groyne or a land reclamation does not change the beachfront property boundaries.

3. An owner has a right to protect his land, even though such works may cause damage to adjacent properties. And adjacent properties cannot claim compensation.

A look at condition number three shows that it is certainly not in the best interest of the islands which turn to Common Law for conflict resolutions. It would be better to examine current legislation and conditions existing on the beach and place regulations that will allow for sound coastal management systems and reduced conflicts.

ACCESS TO GRENADA'S BEACHES

Most if not all of our beaches can be accessed from public roads. In some cases, access is by scant pedestrian trails established by user rights, others are motorable. Pedestrian access is sometimes seen as an inconvenience, particularly to residents with motor vehicles and boats. The provision of motorable roads gives access for the illegal removal of sand from the beaches.

There is more to the beach than just seawater and sand. The beach is an ambience which includes trees, birds and other flora and fauna. That is, the greater environment. This is what locals seek when they go to the beach. When this is replaced by buildings, beach chairs, umbrellas and other activities, that take away from the desired ambience, access is seen as having been restricted.

The imposition of a development setback policy would ensure the preservation of the beaches natural character as all development would take place behind the setback line. In Grenada, only the Grand Anse beach has a setback policy. Basically, the setback policy for Grand Anse means that all new developments at Grand Anse must be set back a minimum of fifty (50) meters from the present high water mark. High water mark is here defined as the upper limit to which the water reaches under normal conditions.

COMMUNITY INVOLVEMENT

It bears mentioning that beach management means nothing without community involvement. All stake holders must be involved. Often, beach management amounts to crisis management, that is, only when there is a crisis are regulations and controls put in place.

With the increased pressure for development of our lands, the need for beach management is essential. The related benefits are obvious, namely safeguarding our heritage and leisure space, ensuring the sustainability of the tourism industry and conserving our precious coastal ecosystems.

When the different stake holders - the Government and private sector, resident beach users and hotel owners, fishermen and divers - come together to solve conflicts and develop management approaches, the responsibility and benefits are shared by all. If not, the present problems will be exacerbated if we do not manage our beaches for posterity.

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MANAGEMENT OF MARINE TURTLE NESTING BEACHES ON WEST INDIAN ISLANDS

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ABSTRACT

The nesting habits and populations of the four species of sea turtles that nest on Caribbean beaches are described. The paper discusses ways to manage and conserve these populations. The foremost threat to marine turtle survival in the Caribbean is hunting and poaching. While legislation and enforcement are important aspects of management, experience has shown that education and peer pressure are the best weapons against poaching. Sea turtles also face indirect threats from human population growth and coastal development. Management practices for beach lighting, coastal revegetation, beach renourishment and beach cleaning are discussed in the context of habitat conservation.

INTRODUCTION

There are four species of sea turtles that nest on West Indian beaches. The hawksbill (*Eretmochelys imbricata*) is the most common and nests on virtually every island including those with intermittent beaches such as Saba (Netherlands Antilles) and Desecheo (Puerto Rico). West Indian island countries with substantial numbers of nesting hawksbills include the Grenadines, Dominican Republic, Jamaica, Cuba, Antigua, Puerto Rico and the U.S. and British Virgin Islands (Mager, 1985, NMFS and USFWS, 1993).

Hawksbills may nest and hatch out at any time of the year, however, nesting is usually from June to December with hatching continuing through February. The hawksbill's indiscriminate choice of beaches - from pocket beaches fronted by coral reefs and beach rock, to long beaches with sand offshore - makes it difficult to rule out any beach as a prospective hawksbill habitat. Their nests are shallow, often less than 25 cm from the sand surface, and therefore prone to disturbances from above.

Hawksbills usually nest under woody vegetation or very close to it, and may crawl 10 m or more into the vegetation. Some common plants hawksbills nest under in the northern Caribbean include bay cedar (*Suriana maritima*), sea grape (*Coccoloba uvifera*), coin vine (*Dalbergia ecastaphyllum*), cocoplum (*Chrysobalanus icaco*) and the Australian pine (*Casuarina equisetifolia*). Hawksbills do not generally nest colonially, but are dispersed both spatially and temporally, thereby making it more difficult to protect them and their nesting habitat. They are quite sensitive to human presence and prefer to nest on small isolated beaches, often on offshore cays. Because of their isolated nesting habits, new hawksbill nesting areas are still being "discovered."

The pelagic leatherback (*Dermochleys coriacea*) migrates from colder waters to many Caribbean islands to nest. The two major nesting areas in the West Indies are Trinidad and the Dominican Republic, but nesting also occurs in Puerto Rico and St. Croix, and to a lesser extent in the Grenadines and St. Lucia (Mager, 1985). Although a beach may have only one or two nesting females, each female has the capacity to nest 10 - 11 times in a season, and may return to the same beach every two or three years.

There has been a gradual, but substantial increase in nesting at Sandy Point, St. Croix in the last 15 years. When research and protective measures began in the early 80's an average of 20 females nested annually - now that number has increased to 35-55 females a year. There appears to be a similar trend occurring in Puerto Rico, where some nesting beaches have been protected since the mid 80's. Large increases were also observed in Trinidad from the 60's to the 80's (Pritchard, 1989). Unfortunately considerable decreases have been noted in other areas such as the British Virgin Islands, where leatherback protection only began in 1986 (Cambers & Lima, 1990).

As opposed to the hawksbill, the leatherback generally chooses longer, wider high-energy beaches with sandy approaches. This species is not as perturbed by human presence and development, and will often nest on populated lighted beaches. It usually nests on the open beach platform or in sparse vegetation composed of vines such as beach morning-glory (*Ipomoea pes-caprae),* beach pea (*Canavalia rosea*), or grasses such as seashore dropseed (*Sporobolus virginicus*).

Although green turtles (*Chelonia mydas*) are often found grazing on sea grasses and algae in West Indian waters, few islands have any appreciable nesting with the exception of Aves. Colonial nesting occurs on this uninhabited sandy cay 220 km west of Dominica. Governed by Venezuela, the four hectare island was declared a wildlife refuge in 1972. Substantial nesting also occurs in Trinidad (Ogren *et al*, 1989), the Dominican Republic, the Grenadines, and Jamaica (Mager, 1985). There are still areas that have not been adequately surveyed such as Anegada (BVI), and nesting seems to be increasing in St. Croix and some offshore islands of Puerto Rico. West Indian colonies that have been virtually extirpated existed in Cuba and the Cayman Islands.

Green turtles prefer high-energy beaches with deep sand, and nest from March to December on Aves Island (Hopkins & Richardson, 1984). In St. Croix the peak of the season is in mid-October. Green turtles are perturbed easily, especially by movement on the beach, and will avoid beaches where artificial lights are visible (Mortimer, 1982).

The loggerhead (*Caretta caretta*) is not widely known for nesting in the West Indies, however nesting occurs in Cuba (Ogren *et al*, 1989), Jamaica, the Grenadines, and the Dominican Republic (Mager, 1985). They nest in scattered grassy dune vegetation during the summer months. Although little is known about Caribbean loggerheads, a great deal of research has been done in the southeastern U.S.A., which supports the largest population in this hemisphere.

The four above-mentioned species are listed as vulnerable or endangered by the IUCN Red Data Book, and are listed in Appendix I (threatened with extinction) in the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES, 1973). Marine turtles are migratory and do not recognize national boundaries. They are a shared island resource and through international cooperation they may ultimately survive.

MANAGEMENT RECOMMENDATIONS

Management begins with a good beach monitoring program. As primary goals, managers should determine nesting species, density and favored beaches. Only from long-term studies will yearly fluctuations and population trends be deduced. Favored beaches can then be considered for special protection, and island-specific threats to turtles, eggs, or hatchlings can be minimized.

Legislation and Enforcement

The foremost threat to marine turtle survival on many Caribbean beaches has been and often still is hunting and poaching. Establishing laws to protect nesting females and their eggs is a start, however, there are often difficulties with enforcement. Usually there are not enough personnel and vehicles to patrol the beaches. Cultural differences between urban lawmakers and rural resource users can be a problem (Gomez, 1982). At times those in charge of surveillance at the beach may overlook offenders, or worst yet partake in the same crimes. When poachers are apprehended, local judges can be too lenient. Judges may be ignorant of the law or perhaps sympathetic to the offender. In many countries the fines are small in comparison to the profits that can be made on sea turtle products in the black market.

Difficulties with enforcement can result from inconsistencies between central governments and separate island governments. For example in Puerto Rico (U.S. Commonwealth), offenders may be penalized under local law or federal law, with quite different consequences. The agencies may squabble over who has jurisdiction in such a case. Another example is the Netherlands Antilles, which has diverse legislation existing on three levels - the Kingdom of Holland, the central (Netherlands Antilles) government, and the various island governments (Sybesma 1992).

Education

Experience has shown that in the long run education and peer pressure are the best weapons against poaching. Teaching children the life-history of sea turtles and the reasons they need protection can instill an enduring conservation ethic. Many older fishermen and coastal residents have seen the decline of turtle populations in their own lifetime and are often the first to convince others of the need for conservation. When a community starts to protect "their" turtles, a poacher often becomes *persona non grata*; and the increase in local pride causes a gradual shift to non consumption. Living turtles become the focus of science fair projects, independent studies and eco-tourism.

Islanders often resent what they perceive to be the intrusion of big government, therefore non-governmental organizations (NGO's) can often be more effective in education and protection at the grass roots level. Slide presentations (especially with local turtles and people as subjects) can be given at schools, college, fishing associations, government agencies (e.g. Coast Guard), and civic and church groups. It is helpful to have available printed materials such as brochures or posters. Displays with preserved turtles and photographs work well at environmental fairs such as Earth Day celebrations.

Permanent displays can be mounted at ports of entry and nesting beaches. Turtle watches, if properly handled to avoid harrassment, make a lasting impression. Brochures can be made available at coastal resorts to minimize tourists' impacts on the nesting beach. For example, the brochure can warn people not to carry hatchlings to the sea, because this circumvents an important part of the orientation process. The Center for Marine Conservation in Washington, D.C. (USA) has a brochure entitled "Attention Beach Users", which can be modified to suit a particular island's needs, as has been done successfully by a Greek NGO.

Natural Threats

Natural threats to turtles can be classified as biotic and abiotic. Due to low biodiversity, predation is usually minimal on islands. The greatest threats to eggs and hatchlings are introduced species such as mongooses, rats, dogs, feral pigs, and fire ants. Population control, and fencing systems that either protect individual nests, entire beaches, or hatcheries have been used successfully to avoid predation.

Fencing nests or beaches is preferable to transferring eggs to hatcheries, because of the risks involved in handling eggs and changing the natural nest environment. A 1.5 X 1.5 meter square of fencing or screening material with holes big enough for hatchlings to escape can be secured flat over nests to ward off large predators. Fences can be erected around nests to prevent vehicles and pedestrians from crossing over nests, especially near hatching time. This type of fence should have a gap at the bottom large enough for the hatchlings to crawl under. Four posts and a rope can often serve the same purpose. If poaching is a problem, timely monitoring of the beach and camouflaging turtle tracks can be effective.

Abiotic hazards include saltwater inundation from erosion or storms, and freshwater inundation from flooding. If these dangers are anticipated, nest translocation can be a useful tool if carried out properly and promptly. Egg collection should occur during laying or within six hours of laying. If eggs must be moved after this time, the top of each egg should be marked with a pencil, and at no time should an egg be rotated from this axis during the moving process (Pritchard *et al*, 1983).

It is best to select another site on the same or a nearby beach, and to dig a hole as close as possible to the original dimensions. Hatcheries fell out of vogue after it was discovered that nest temperature determines sex in sea turtles. Therefore, monoclimatic hatcheries have a tendency to produce hatchlings of the same sex, instead of a natural sex ratio. Also land-based and marine predators may be attracted to the concentrated banquet of eggs or hatchlings at a hatchery site.

Developmental Impacts

Direct threats to turtles on many islands have been replaced by indirect ones primarily as a result of human population growth and coastal development. Islands with laws protecting turtles often lack laws protecting turtle habitats. Artificial lights are a serious and escalating problem. Lights can inhibit adult turtles from nesting, and can attract hatchlings and cause disorientation, circumventing their normal sea-finding behavior. Disorientated hatchlings often die from predation, being hit by cars, or desiccation.

Research on species-specific effects of light is ongoing, however, the general consensus is that no lights shining on or near the beach is the ideal solution for sea turtles. Fortunately there is a compromise for planners and developers. Out of all lights tested, one type of luminaire has been found not to disorient hatchlings at normal wattage - the low pressure sodium (LPS) vapor, or pinkish-orange street light common in many areas. High pressure sodium vapor is not an acceptable substitute for LPS, however, low intensity yellow "bug" lights are fairly safe to use (Nelson and Dickerson, 1989).

If necessary, other luminaires can be used or modified in one or more of the following ways - shielding and screening (with metal, wood, vegetation etc.), redirecting (aiming downwards and away from the beach), lowering light, lowering intensity, or limiting hours of use. For security purposes, motion sensitive lights are an excellent choice, because they only illuminate when something passes by and then they shut off automatically. In Florida, USA, many municipalities have developed lighting ordinances. Brochures are available for coastal residents explaining the problem and solutions.

Another area that can be managed is the deforestation of our coasts. Dune vegetation plays an important role in stabilizing shorelines, providing habitat for nesting hawksbills (and other animals), and buffering lights and development. Wooden dune crossovers help prevent foot traffic from trampling plants. Resorts and residents often strip vegetation for a better view of the ocean, and to have a cleaner looking beach. This trend needs to be halted and reversed if at all possible. Set-backs for buildings, roads and sand-mining operations should be implemented and enforced.

Restoration of dune vegetation with native species is desirable. Exotics such as the Australian pine have caused extensive damage to coastal areas in Florida and are now prohibited (Nellis, 1994). Although this species grows quickly, in the long run it can cause erosion, because it does not allow undergrowth of grasses and low bushes. Additionally hawksbills have difficulty nesting beneath Australian pines because of the root structure. Dune reforestation projects should begin with grasses, because of their ability to grow upwards as the dune accretes. Nellis (1194) explains methods of propagation for seashore plants.

Erosion can be escalated by sand mining, man-made structures (e.g. jetties) and catastrophic events such as hurricanes. Armoring of beaches with rocks or cement is detrimental to turtle nesting unless sand is added to sufficient depth for nesting. Badly eroding beaches can be hazardous to turtle nests, however, extreme caution must be used when renourishing a beach. Because turtle nesting can occur year-round, a constant vigil would be necessary to identify and move any nests before they were covered over.

The physical characteristics of the new sand should be as close as possible to the natural beach sand, which plays an important role in hatching success of turtle eggs. For example greater compaction occurs on new beaches where fine angular sand is dredged from offshore borrow sites; while looser beaches result from coarse grains dredged from high-energy sites such as inlets (Nelson and Dickerson, 1989). beach compaction is a serious problem that can impede turtle nesting for a number of years until the sand is reworked by natural processes.

Beach compaction can also occur from vehicles driving on the beach, and this can prevent hatchlings from digging their way to the surface. Vehicles can crush hatchlings, and their tracks can trap hatchlings. Vehicles should not be allowed on turtle nesting beaches, except for light weight all-terrain vehicles used for research or emergency purposes. These should be driven near the water's edge, and not across dunes or vegetation.

Mechanical beach cleaning equipment can be hazardous to the shallow nests of hawksbills, and has a tendency to remove low-lying vegetation. Beaches should be cleaned by hand and beach cleanups can be organized by the community. Trash on beaches can entangle wildlife and attract pests that prey upon eggs and hatchlings. Lawn chairs, rental boats, and other resort equipment should not be left on the beach at night.

Large developments (tourist, residential or industrial) should draft habitat conservation plans as part of the regulatory process to insure sea turtles' protection from the threats listed above. An island which chooses to protect its marine turtles and nesting beaches will be protecting a number of other flora and fauna coincidentally. As Frazer (1985) reminds us "The rapid development of facilities to house, feed and entertain tourists should not be allowed to destroy the beauty that first attracted them to the Caribbean." Sometimes we do not know what we have until it is gone.

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GRACE BAY REVISITED, PROVIDENCIALES

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ABSTRACT

The impacts of tourism in Grace Bay, Providenciales, is discussed. Physical development and local plans have targeted this bay for tourism development. There are four major hotels and several smaller ones, most were completed before environmental impact assessments were mandated for such major projects. Development has taken place in the shoreline reserve (60 feet back from the high water mark) and dunes have been destabilised. The number of beach accesses has decreased, nearshore waters have become contaminated with sewage and liquid wastes and coral reefs are under threat. Several planning and institutional strengthening recommendations are proposed to mitigate these impacts.

INTRODUCTION

Local beaches revisited is a most awakening experience for a returning resident. The beaches, which were previously areas of seclusion, tranquillity, nostalgia and cultural events, are now becoming crowded with hotels, tourists, yachts and host facilities e.g. boat rides, water-skiing, parasailing, tiki-huts, parasols, deck chairs, sunbeds, etc. It is a typical case of serious, rapid moving social, environmental and cultural change, for many of the indigenous population of host countries.

To the indigenous person, going to the beach, which was previously a social event with cost only incurred in purchasing food and drinks for consumption, has become a recreational activity, requiring trendy designer accessories and gear (swimwear and sunglasses) at unaffordable prices.

In prime beach areas, open spaces have either disappeared completely or have dwindled to footpaths. Most of the existing footpaths are under pressure to accommodate the expansion of tourism related development or have been removed altogether, especially in high profile, low density, residential areas. Wherever their locations, many of the locals are reluctant to venture onto the beach accesses, because of their poor legibility which gives a feeling of intrusion.

Tourism and other sectors of development, which are expanding on the island, are threatening to destroy those very features which now attract tourists to the island.

This study assesses those impacts with specific focus on ownership, access, safety and user conflicts in the Grace Bay area of Providenciales. The study also make recommendations for the future, which would ensure a more sustainable approach to tourism related developments.

DESCRIPTION OF THE TURKS AND CAICOS ISLANDS

The Turks and Caicos Islands are located at the extreme southeast end of the Bahamas chain of islands, approximately 575 miles from Miami and 90 miles north of Hispaniola (Haiti and Dominican Republic).

The islands consist of two distinct groups: the Caicos Islands, approximately 60 miles by 30 miles, comprised of South Caicos, Middle Caicos, North Caicos, West Caicos and Providenciales; and the Turks Islands, consisting of Grand Turk (the capital of the entire Turks and Caicos Islands) and Salt Cay. Apart from these major islands, there are numerous other smaller cays.

The total population of the Turks and Caicos Islands is approximately 12,350 persons. Of this total, the majority are concentrated on the island of Providenciales, followed by Grand Turk, with the rest of the population scattered throughout the other islands, with the least on the island of Salt Cay. The island of Grand Turk had the highest population until the early 1980's when the tourism boom began on the island of Providenciales creating opportunities for employment and higher incomes.

The Turks and Caicos Islands are among a few small territories in the Caribbean (Anguilla, British Virgin Islands, Cayman Islands and Montserrat) which are still British Crown Colonies. The Turks and Caicos Islands received its present constitution in 1976. This constitution puts more power in the hands of the local assembly, making the Islands much more masters of their own future and giving the Islands a party system of government, with the leader of the ruling party appointing ministers to various portfolios.

BACKGROUND

The islands, unlike many other Caribbean islands, do not have many natural resources which they can use to generate great economic returns. Compare for example, the mining of bauxite in Jamaica, the production of oil in Trinidad and the agricultural base elsewhere in the Caribbean. The islands do possess, however, an all-year-round warm climate and seaside locations which are suitable for tourism.

The potential for tourism has been recognized and a Turks and Caicos Tourism Development Plan (1986) has been prepared. In addition to the Tourism Development Plan, other plans have been prepared. A National Physical Development Plan (1987 - 1997) has been prepared, accompanied by Local Plans for a number of individual islands. One of the main points of the proposed development for the islands, as stated in the National Physical Development Plan (1987 - 1997) is that "Providenciales will be the centre of major tourism development. The existing and future investment in hotels, condominiums, resort villas, marinas and commerce will create job opportunities."

In order to secure "the most attractive and economical form of development", the Providenciales Local Plan (1987 - 1997) targeted Grace Bay as one of the few areas where tourism related developments would be encouraged in clusters. The majority of the recreational facilities that tourists expect, such as boating expeditions, scuba diving, fishing excursions, golfing and other sporting activities are all located in the Grace Bay area, as are many of the restaurants and gift shops that cater to tourists. The hotels in the Grace Bay area are Sandals (200 rooms, with plans for expansion), Club Med (300 rooms), Turquoise Reef formerly the Ramada Hotel (228 rooms), Grace Bay Club (96 rooms) and Le Deck Hotel (26 rooms). A 24 bedroom condominium project is nearly completed (The Mansions) and 5 major condominium and hotel projects are currently seeking the necessary planning approvals to commence construction. Together with all the aforementioned tourism related developments, there are many high cost, low density residential developments in the Grace Bay area.

The islands' ecosystems are exceedingly fragile, and the land and sea environments are intimately inter-related. There are extensive and complex biophysical links between terrestrial and marine ecosystems. Therefore, as indicated in the National Physical Development Plan (1987 - 1997): it is essential to consider these ecosystems as linked parts of an integrated environmental system.

The terrestrial environment of the area is not considered to possess any special scientific qualities other than the ground water reserve and the natural landscape whose uniqueness has already been impacted. Therefore it is argued that there are no economic benefits to be derived with the land in its natural state.

PROBLEMS

The welfare of Providenciales ultimately depends on the terrestrial, wetland and marine components of the natural environment. A depletion of productivity in the natural environment would probably result in a diminishment of the life support systems to both human and natural communities. It is the natural environment which ensures continued economic returns for Providenciales, especially from tourism.

Since the early 1980's, Grace Bay has witnessed an explosive growth in tourism related developments. Most of the major projects had either already obtained the necessary planning approvals, commenced construction or been completed prior to 1990, without the submission and implementation of an adequate environmental impact assessment (EIA) study, which would have assessed the socio-economic and environmental components of the particular project.

Until recently, Section 63 (1), of the Physical Planning Ordinance, 1989, was the only section of the legislative and regulative planning framework which explicitly made provisions for the proponents of major development projects to undertake environmental impact assessments. The aforementioned provisions are specially directed towards development in conservation areas. Section 32 (1) (b) of the Ordinance, 1989, gives the Director of Planning the authority to determine at his discretion, whether an environmental impact assessment study shall be required for a project, prior to the assessment and determination of an application(s) for the requisite Detailed Development Permission and Building Permit. The Development Manual, 1995 (Revised April, 1996) makes specific reference to projects for which an EIA study is required. Guidelines and policies are contained within the Manual relating to beaches and coastal areas, environmental protection, beach access and open spaces.

Among the environmental and ecological problems encountered in Grace Bay, are problems of a social nature, including access, ownership and safety, brought about as a result of the development of tourism, without adequate technical and human resources.

Degradation of Beaches from Development too close to the Shoreline

Coastal sand-dunes are very vulnerable geological features which can be easily eroded by over-use or poorly sited development. They are important components of the coastal protection system.

Prior to the implementation of guidelines for development in coastal areas (Section 3.4.2.1 & Chapter 4, of the Development Manual, 1996) and in spite of its current existence, residential and tourism related developments have continually been undertaken callously and insensitively. Notwithstanding the minimum setback of buildings, 60 feet, from the high water mark, the provisions of Section 4.2, of the Manual, permits boat houses and changing facilities to be constructed within the shoreline reservation. The interpretation is that swimming pools are also permitted under the provisions of Section 4.2.

Nearly all developments, hotels, resorts and residential, have their swimming pools, gazebos, dive shops and similar structures located within the shoreline reservation. In the same areas, up to 80 feet back, are sandy soils which formed as a result of accretion. These activities are resulting in the degradation of the sand dunes. The development on land, which formed as a result of accretion, is exceeding the carrying capacity. Hence the loss of sand is already evident as the sea begins to reclaim some of the area, exposing building foundations.

During the construction of residential and tourism related developments, there is a tendency to clear the land totally of all natural vegetation. This includes the building site and the surrounding area. In natural conditions, most sand dunes are stabilized by vegetation. If the vegetation is removed, the dune material is no longer bound by the roots of the vegetation and it is easily moved by wind and water action and erosion results.

Beach Access and Open Spaces

Section 60 (1), of the Physical Planning Ordinance, 1989 and Sections 4.7 & 4.8, of the Development Manual, 1996, make provisions for open spaces or public access areas. These are registered and are indicated on all Block Plans (cadastral maps) of the area. The Department of Environment and Coastal Resources, in cooperation with the National Trust embarked on an ambitious project to erect sign posts on all the beach accesses. Soon after their erection, most of the signs were defaced or removed altogether, reportedly by nearby residents.

Many of the accesses have become footpaths only. Most of the existing footpaths are under pressure and may be lost to tourism and other forms of development, especially in high profile, low density, residential areas. Wherever their locations, many of the indigenous locals are reluctant to venture onto the beach accesses because of their poor legibility which gives one a feeling of intrusion.

Contamination of the Coastal and Marine Environment

The most alarming occurrences, associated with massive growth in tourism related developments in the Grace Bay area, are sewage disposal and the poor drainage of contaminated liquid waste. All future development will require adequate sewage disposal infrastructure and drainage systems to properly dispose of pollutants. Failure to observe this requirement may result in the irreversible pollution of beaches and bathing water and the destruction of marine life.

Many of the older hotels still use the septic tank and soakaway method of sewage disposal. This method will cumulatively impact on the ground water. Currently no testing is carried out to determine the water quality. All the recent hotels (Club Med, Turquoise Reef Resort & Casino Hotel, Grace Bay Club and the Sandals Resort) have treatment plants. The Club Med treatment and disposal system is causing odour problems. This is due to inadequate maintenance and servicing. It is a requirement of the Department of Planning, for all future hotel development to have mechanical treatment plants that are properly maintained during the operational phases of the development.

Destruction of Coral Reefs

In Grace Bay, the reefs are viewed as a commercial resource, a significant asset to the tourism industry particularly for recreational diving and snorkeling. Given the rapid growth and commercialization of the Grace Bay area, it is shocking and appalling that a long-term integrated management plan has yet to be implemented. This is a major cause for concern, since ironically the Princess Alexandra National Park, encompasses the marine environment bordering the Grace Bay area.

There is very little evidence of significant reef and other marine species destruction, but this should not result in us becoming complacent. The Department of Environment and Coastal Resources have recognized potential threats to the nearshore reef systems that can result from tourism activities. These threats include the breaking of coral for souvenirs, anchor damage to reefs from boats and pollutants from the terrestrial environment.

CONCLUSION

The problems associated with the activities outlined above will continue as the growth of tourism increases. How much tourism development is to be planned for in the future will depend upon the islands ability to maintain itself as an attractive tourist destination. The employment and income generated by the tourism sector are greatly needed in the economy. In order for the island to remain competitive in the tourism market, one of the key objectives is for the island to maintain its basic environmental quality. This is often what attracts the tourists in the first place.

RECOMMENDATIONS

1. There is the need for strategic environmental impact assessment as part of the development plan preparation which will redirect incompatible uses to more suitable locations.

2. There is the need for visual quality landscape evaluation in the planning system on the island. The scenic qualities of the coastal landscapes should be protected as a resource which is in limited supply.

3. Large-scale developments should be prohibited from proceeding without proper planning approvals and environmental studies such as environmental impact assessments.

4. The marine environment should be included within an overall planning framework, which would help overcome sectoral thinking. This has led to terrestrial based activities adversely affecting the quality of marine systems and hence, their potential productive use.

5. Strengthening of environmental agencies is required. Bilateral and multilateral organizations must be prepared to provide increased assistance for institutional development.

6. Departments concerned with the management of the natural environment, should develop an integrated approach to planning, thus bringing together the various agencies and users of the resource.

7. Stronger political support from the general populace is needed.

8. Extensive baseline studies need to be carried out in the area so that informed opinions can be made regarding future trends.

9. A plan, encompassing principles of sustainable management, should be compiled and implemented for the Grace Bay area, for use by planners, wardens and other environmental managers.

10. Plans and legislative requirements need to be capable of adaptation to meet changing conditions.

11. The training of enforcement officers to a minimum level of first degree shall be mandatory in order to attract competent individuals.

12. Technical assistance is needed for updating and revising existing planning policies relating to coastal areas.

13. Adequate financial resources need to be made available to the management agencies and departments.

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D. THE MANAGEMENT OF BEACHES AS A TOURISM RESOURCE

DESTROYING THE GOOSE THAT LAYS THE GOLDEN EGG

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ABSTRACT

The unprecedented increase in economic development in Anguilla in the last decade has been due to an expanding tourism industry. However, this industry may be destroying the resources upon which its economic sustainability depends. Land clearing with the resultant increased sedimentation on the reefs, the replacement of natural vegetation with exotics requiring considerable doses of fertilizers, indiscriminate sand mining, the alteration and destruction of dunes and the lack of adequate development setbacks are all threatening the natural coastal resources of Anguilla upon which the tourism industry is based. The situation has not yet reached crisis point in Anguilla for the island still has many pristine beaches and coastal areas, nevertheless this does not provide grounds for complacency since increasing development pressure could change the situation in a short space of time.

BACKGROUND

Since the early 1980's, Anguilla has experienced a significant increase in economic growth. The gross domestic product in current prices increased by an annual average of 16% from EC $ 47.06 million in 1985 to EC $165.1 million in 1995. The unemployment rate, which was 26% in 1984, had dramatically decreased to 1% in 1989, though it was estimated to be about 7% in 1995 (Anguilla Statistical Unit, 1995).

This unprecedented increase in economic development is undoubtedly due to an expanding tourist industry. Visitor arrivals on this tiny Caribbean island of approximately 9,000 people, had jumped from 17,561 in 1982 to 125,780 in 1994. In 1985 the contribution of the hotel and restaurant sector to the gross domestic product was EC $13.2 million (28% of GDP). By 1994, the figure had increased to EC $60.76 million (36% of GDP).

Undoubtedly, the single most important tourist attraction of the island is its pristine environment, including the 32 spectacular white sandy beaches. Consequently, much of the tourist related development is concentrated in the beach areas. While this tourist related development around the beaches creates employment and generates wealth for the residents of Anguilla, it is resulting in the degradation of the beaches. Tourism can be economically self defeating since it destroys the very resource upon which its economic sustainability depends. In other words, tourism itself is destroying the goose that lays the golden egg.

This paper is therefore a discussion of the ways in which unsustainable tourism development policies and practices are directly and indirectly, destroying the beaches of Anguilla.

BEACHES AS PART OF THE ECOSYSTEM

It must be recognised that beaches are part of a wider ecosystem which includes inland areas such as mangrove, as well as seagrass beds and coral reefs. Damage inflicted on any element of this ecosystem will most likely have a negative impact on the beaches. For example, mangrove and other natural vegetation act as sediment traps thus reducing the amount of mud, silt and other debris reaching the inshore reefs. If these mangroves and other natural vegetation are cleared, the resulting sedimentation will smother the coral and reduce the amount of light reaching them. This eventually destroys the coral reefs. Every effort must be made to avoid this occurrence in Anguilla, since these reefs act as natural breakwaters which reduce the amount of erosion occurring in coastal areas during ground seas and hurricanes. Coral reefs are also a major source of sand for the island's beaches.

Unfortunately, many local residents and foreign developers do not appreciate the importance of the various elements of the wider coastal ecosystem and so indulge in various practices which are now resulting in the degradation of the island's beaches. In many parts of the island, large tracts of land are being completely cleared for hotel development, which sometimes never occurs, or in some cases, occurs long after clearing has taken place. Foreign developers often refer to the specially adapted scrub like vegetation as having little value and should therefore be replaced by less functional exotic plants requiring huge doses of fertilizer (with disastrous consequences).

There is the case of two local fishermen who were found cutting down the trees just behind the foreshore of one of the beaches. When confronted, the two fishermen politely explained that they were securing sticks to construct their fish pots. One further explained that they were helping to develop tourism by clearing the vegetation and making the beach look "nice". The sad fact is that by obtaining the fish pot sticks from this source, they were removing vegetation, allowing mud to enter the sea and ultimately destroying the inshore reefs, the breeding grounds for the same fish they were preparing to catch. At the same time they were indirectly depriving the beach of its future source of sand and protection from ground seas and hurricanes.

Indications are that during Hurricane Luis in 1995, inshore reefs which may have been exposed to greater man made impacts, were more eroded than reefs offshore (Bythell and Buchan, 1996). It also was observed that beaches on the north western coast suffered more erosion than beaches on the southern coast. One of the main reasons for this could have been the absence of any significant coral reef protection system along the north western coast.

It is therefore important that we do not only discourage those development activities which have a direct negative impact on the beaches, but also those which negatively impact on any part of the coastal ecosystem.

SAND MINING

The boom in the tourism industry resulted in a greater demand for sand to build hotel facilities. The boom also provided residents with greater employment opportunities and more wealth, and so they too built more homes and more commercial premises. These also required more sand. The demand for more sand resulted in indiscriminate sand mining and the consequent clearing of coastal vegetation around the island.

Sile Bay on the south eastern coast, is a glaring example of a lovely beach completely destroyed by sand mining. This beach was once backed by an extensive area of sand dunes about 20 ft. high, which were largely mined in the early 1980's. One of the land owners then tried to prevent erosion of the mined out area by constructing a low concrete wall. However, it appears that this wall may be preventing accretion from occurring. The situation at Sile Bay was compounded during Hurricane Luis. With the *Acropora palmata* reef offshore reduced to rubble, the remaining portion of the dunes were swept away and the sea encroached 150 ft. inland.

Meads Bay at the western end of the island's north coast, one of the island's premiere beaches, also suffered severely from sand mining. The beach, which is home to one of Anguilla's five star hotels, is scarred by a number of sand pits. One area was so badly mined that the sea breached the lowered dune and connected with the pond about 250 ft. inland. The Government of Anguilla finally responded by acquiring the parcel of land and rebuilding the dune.

The beaches were so ruined by sand mining that the Government of Anguilla took the ultimate step in 1994 and prohibited sand mining at all beaches except at Windward Point at the eastern end of the island. However, some unauthorised sand mining still occurs.

With the plans for a new international airport, a projected increase in the number of hotel rooms and with the dwindling supplies of sand at Windward Point, there will be considerable pressure to resume the mining of sand on the beaches, unless an alternative source is found. This would considerably weaken the island's ability to attract large numbers of tourists.

SET BACKS

In order for Anguilla to maintain its image as a high quality destination, it must maintain its clear blue waters backed by long wide stretches of sandy beaches, free of any structures. Unfortunately, this is changing. Some developers are being allowed on appeal to build too close to the high water mark.

Beaches are dynamic features. When beaches accrete, the high water mark extends seaward. As the beach erodes, the high water mark recedes inland. Therefore, if structures are erected close to the high water mark, there is no room for the beach to move inland when erosion occurs. This results in the narrowing of beaches and possibly their disappearance.

Data collected under the ongoing beach monitoring exercise carried out by the Department of Fisheries and Marine Resources in Anguilla and the COSALC programme, show that our beaches are eroding. This is particularly disturbing when one considers the predictions for global warming and the consequent rise in sea level. This combined with the degradation of the reef system, our natural breakwaters and suppliers of beach sand, points towards the increased erosion of the coastline.

Hurricane Luis has shown quite dramatically the importance of having adequate set backs of buildings from the high water mark. Several properties were left projecting onto the beach. One notable example is Frangipani Beach Club which had the front portion of the main building completely destroyed. A portion of the building, which has since been rebuilt, now projects onto the beach. This has narrowed that portion of the beach.

Many of the owners of properties which were badly eroded or which had structures that were badly damaged, rushed to take a number of measures to protect their properties and the structures on them. Many of the measures will have very serious impacts on the beaches they sought to protect. One landowner, in an attempt to reclaim his beachfront property, dumped mud and stones in front of some villas on one of the island's best beaches. Much of it was eventually washed out to sea during the "ground seas" season (period during the winter months when high swell waves affect the Lesser Antilles). Other land owners applied for permission to build seawalls in front of their properties. These expensive walls detract from the aesthetics of the beach and thereby reduce the overall quality of these crucially important resources. These "protective" walls which have been built in what is now the active zone, will hinder the landward movement of the beach and may themselves cause further beach erosion, particularly on the adjoining properties.

Cap Juluca is a four star hotel located on the dunes at Maundays Bay. As Hurricane Luis proved, it was inadequately set back from the vegetation line. The beach was severely eroded and the dunes retreated by approximately 20 ft, losing approximately 30,000 cubic yards of sand in the process (Coastal Systems International Inc., 1995). Luckily, most of the sand was deposited in the shallow bay offshore. With the tourist season beginning within a few months of the hurricane, and with structures perched precariously at the edge of the eroded dunes, Cap Juluca was not prepared to wait on the beach to rebuild naturally. They therefore sought and obtained permission to dredge sand from the bay to reconstruct the dunes. Unfortunately, they were allowed on appeal, to dredge without the use of silt curtains . The settling ponds also proved to be too small. This resulted in unacceptable levels of silt entering the sea and may well have caused some damage to the seagrass beds and coral reefs offshore.

The point to be stressed here, is that if the buildings were set back adequately in the first place, there would have been no need for the use of expensive engineering solutions which detract from the quality of these beaches and which may very well cause long term damage.

"RECONFIGURATION OF DUNES"

Dunes in Anguilla perform a very important function. They act as a natural barrier thus protecting coastal areas during hurricanes. The sand from these dunes is also released to nourish beaches. Therefore they must not be seen merely as large sources of sand to make way for development.

This role of the sand dunes became more apparent with the passing of Hurricane Luis. It is believed that the south coast beaches suffered less erosion because they are backed by much higher dunes.

Unfortunately, the island's dunes are not only being built on. At Rendezvous Bay, for example, a developer was allowed to reduce the dunes from a height of 20 ft to a height of 10 - 12 ft and to push them landward. The developers clearly wanted guests in the rented accommodation to have an unobstructed view to St. Martin, a wider sand beach and easier access to the beach in front of the dune. Some years earlier, dunes nearby were also lowered to make room for another hotel project. It was not surprising therefore to discover that with the passing of Hurricane Luis, beaches in this area had narrowed by 18 ft and the dune had retreated by an average of 30 ft (Cambers, 1996).

CONCLUSION

Anguilla is fortunate to be in the early stages of its development and so can benefit from the mistakes made by other islands. While it is clear that in the quest for economic growth, some of the beaches are being degraded, it must be pointed out that by no means has the degradation reached the crisis point. In fact, the island can still boast of having some of the finest beaches in the world, of which many are still in their pristine state. However, there is no room for complacency for with the increasing pressure for development in coastal areas, this can all change rapidly.

It is therefore imperative that certain measures are taken to ensure that development is carried out in such a manner that the beaches are not destroyed. One must therefore ensure that the development policies and practices do not have serious negative impacts on any part of the coastal ecosystem. These include finding an alternative source of sand for the construction industry; ensuring that structures are adequately set back from the high water mark; and allowing dunes to perform their intended function, that is, to be the first natural line of defence for our coastlines during storms. One must also involve the general public. They must be made aware of the fact that their very economic survival is being threatened. If these measures are not taken, then Anguilla is well on the way to destroying the goose that lays the golden egg.

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BEACHES AND TOURISM IN BARBADOS
A PHYSICAL PLANNER'S PERSPECTIVE

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ABSTRACT

International tourism in the Caribbean is largely beach tourism. Its advent has given rise to a series of social and physical problems even though it has brought a good measure of economic prosperity. This paper traces the history of development planning in Barbados since its beginning in the 1950's. While the planning system in Barbados is achieving its objectives in shaping the pattern of land development in the country, it can by no means be said to have overcome all the problems associated with beaches and tourism. Successful physical planning must be a dynamic process capable of responding to constantly changing circumstances. The adoption of Geographical Information System (GIS) technology can assist in providing the rapid responses demanded.

INTRODUCTION

International tourism in the Caribbean is largely beach tourism. Its advent has given rise to a series of social and physical problems even though it has brought a good measure of economic prosperity to most of the islands which previously depended on a mono-crop economy.

Some of the islands, such as Barbados have long practised some form of development planning with the aim of enhancing the benefits to be derived from tourism while minimising the possible adverse impacts. Has planning in Barbados been successful and has it achieved its objectives? Are there lessons for other islands whose planning experience is not as long? Where does Barbados go from here in its efforts to improve?

This paper looks at the physical characteristics of Barbados, the pattern of tourism development engendered by these and other factors, the planning and development control system that evolved, where the situation now stands and the way ahead for Barbados.

BACKGROUND

Barbados is the most easterly of the islands in the Caribbean. It lies 59 degrees west of Greenwich and 13 degrees north of the equator. Its closest neighbours, St. Vincent and St. Lucia, are approximately 100 miles southwest and west respectively.

Unlike its neighbours in the Windward chain, and indeed most of the Caribbean, the island is relatively flat. The land rises in a series of terraces from the coast to its highest point of 1100 feet above sea level. There is also little natural indigenous vegetation except in the Scotland District where is found a small relic of semi-evergreen seasonal forest at Turner's Hall (about 46 acres). This almost complete removal of the natural vegetation occurred within 40 years of the island's settlement in 1627 and was no doubt a consequence not only of the need to capture as much cultivable land as possible but also the inviting nature of the terrain which made the task easy.

The island is pear-shaped. The Scotland District mentioned earlier is the most visually distinctive part of Barbados. It is situated in the northeastern part of the island where the coral cap has been eroded. The terrain is rugged and subject to severe problems of soil slippage and erosion. The highest point in the island, Mount Hillaby, is on the rim of this area.

The north and southeast are flat, wind-swept rocky table lands with rather shallow soils. The best soils are to be found on the upper terraces in the middle of the island, where the soils are deepest and the rainfall highest and in the St.George valley which lies between the upland area and the Christ Church dome to the south. The sheltered coastal areas to the west and south receive the lowest rainfall but provide the most numerous drainage outlets to the sea.

One of these outlets, called the Hole, was the chosen site for the first settlement which became known as Holetown a name it still bears today. The capital was later moved to Bridgetown on the southwest and is itself at the mouth of the Constitution River, probably the longest drainage course in the island.

The exposed east coast of Barbados, stretching from Pico Teneriffe to Cattlewash, contains the most extensive beach systems in the island. The beach is long and wide and backed by a series of sand dunes, some of which extend quite far inland. It is largely by reason of the fortunate occurrence of these inland dunes that the island has been spared the scourge of beach sand mining.

Also of interest is that long before the present upsurge in international tourism to the Caribbean, a part of this area known as Bathsheba and Cattlewash had been established as the seat of domestic tourism for well-to-do Barbadians. It remains so to this day. It is where they go to spend their week-ends, and annual vacation and to recuperate after illness. Smaller sites, also on this coast such as River Bay, Bath and Skeete's Bay enjoyed the same fame. This coast has also been always popular with Barbadians in general for picnics and outings.

The rocky table lands of St.Lucy in the north and St.Philip in the southeast are ringed by vertical cliff faces, indented here and there by small sandy bays. These are generally frequented only by nearby residents who are familiar with the accepted footpaths through private lands and down the steep rock faces.

As the west and south coasts of Barbados presented the natural gateways to the island it should not be surprising that these have been the areas of the earliest and most dense settlements. The entire island was of course covered with sugar plantations with here and there small tracks grudgingly left for passage of man and animal between the fields. These eventually became widened to accommodate animal drawn carts and later motor vehicles.

At those frequent points on the west coast, and to some extent the south coast, where the drainage gullies emptied into the sea there was often ponding. The situation is largely unchanged. There developed certain salt resistant plants, grasses and trees and were the breeding ground for insects and crabs. The fine sandy beaches along these coasts remained largely unexplored and unexploited until recent times.

PATTERN OF TOURISM DEVELOPMENT

In the days when sugar was king, planters made sure that every suitable square foot of land was cultivated. Homes for workers were sited on the steep hillsides or on the water's edge. Ironically, these have now become the most sought after building sites. That is also why you can find luxury hotels on the coast sited cheek by jowl with poor chattel houses which incidentally turn their backs to the water.

The earliest resort hotel in Barbados is said to have been the Crane Hotel which still exists and is sited on a high rocky cliff overlooking the Crane Beach in the southeast. Other early hotels, such as the Ocean View which is also still existing, are to be found on the south coast, on the outskirts of Bridgetown. The Marine Hotel, the largest of these, was only recently demolished to make way for a hotel school. In spite of its name, it was interestingly enough not sited on the coastline though within easy reach.

Barbados began collecting tourist statistics in the mid nineteen-fifties. In 1956 some 17,829 long-stay tourists and 12,301 cruise ship visitors came to the island. They were estimated to have spent U.S.$4 million. Of the long-stay visitors 10,141 stayed in guest houses and small hotels, which were mostly on the south coast, and had a total of 1,190 beds.

Many of these early tourists were wealthy persons from North America and Europe who built palatial residences on the newly discovered west coast. Once the bush and the mouths of the drainage courses were cleared, it was realised that some of the best swimming beaches were to be found in this part of the island.

The west coast established itself quite early as the luxury zone of Barbados and has succeeded in maintaining this character.

The north of the island has never been attractive to tourism developers. One hotel was established there but did not survive and has fallen into ruin.

In the Scotland District, on the northeast, there have from time to time been enquiries and proposals but no development has actually materialised. This area has now been designated a national park and it is unlikely to see any major building development.

The southeast coast where it all started has seen a smattering of development but has never really flourished. There are a few good sites remaining and even at this moment a number of proposals are under consideration.

The south coast was already highly urbanised when international tourism struck. In many instances tourist accommodation was competing with domestic residential usage. Indeed, many of the substantial residences first converted to guest houses then expanded to small hotels. This became the area mostly associated with small sites and dense tourism development.

The road along the coast, particularly the west coast, is in some places, on the water's edge. In many other parts it is no more than one house plot depth away. This strip was also generally well wooded, while cultivated land bordered the other side of the road. Tourism development along the coast was therefore destined to contend with many issues, some of its own making. These included: restricted sites, high land values, drainage and sewerage, road congestion, arable land, open and wooded areas, beach erosion, public access.

Under the Barbados legal system property on the coastline extends to the highwater mark. (Land below the highwater mark is public domain). This means that the boundary is moveable. Some properties have been known to lose land and others to gain. This becomes rather complex on a bay where the extension of boundary lines to claim accreted land can lead to dispute due to the lines tending to converge.

Another characteristic of the coastal property system is that when plantations sold beach lands, rights-of-way were often reserved for those who lived on the land side - them, their servants and assigns. With the passage of time these rights have become public. As a consequence numerous rights-of-way exist from the public road to the beach.

There are other associated problems for example to do with trespass and the building of structures within and on seaward boundaries. Also when these structures become threatened by the sea property owners do not readily accept that they cannot take certain actions to protect their properties.

Although it has been largely ignored for a long time, sewage disposal in an area with a high water table, being on the coastline, and with no mains system, has become a major problem with the development of tourism.

Mention must also be made of the increased pedestrian and vehicular traffic generated by tourists movements on a road system that has not much changed since the days of the horse and donkey carts.

Reference has already been made to the threat to arable agricultural land, particularly in proximity to the coastline. The leading luxury hotel on the west coast as well as an adjoining major apartment and villa complex have been built on former sugar plantations that were in operation within living memory. The current threat to agricultural land which is also of interest to coastal planners is the development of major golf courses even when these are sited well inland.

PLANNING AND DEVELOPMENT CONTROL

The realisation of the need for some government control over these matters came in the late nineteen-fifties. Even though the legislation did not set out to deal with tourism development specifically it is interesting that it was first applied to the west and south coastal areas and the capital city - being the areas most obviously in need of development control.

Barbados can in fact boast of a development control system that goes back to the beginning of the century. As early as 1908 Barbados had a Public Health Act intended largely to deal with the various epidemics that swept the region from time to time. Among its 59 sections were five, Sections 52 to 56, which dealt with the development of land to be let or sold for housing purposes. This followed the British late 19th century practice of tacking town planning on to Public Health legislation. The Barbados Act sought to control the size of lots, the width of roads, the provision of sanitary facilities, water for domestic consumption, and drains for carrying off waste and surface water. The selling price of land was also fixed.

It is however, true to say that until quite recently there was little control over land development in Barbados. The consequences have been many and varied - ribbon development along main highways and fine stretches of coastline, unsatisfactory provision for public and social services, low density sprawl and the loss of prime agricultural land, mal-distribution of land uses and congestion within the city.

In 1959, the Town and Country Development Planning Office was set up to try through comprehensive planning and control, to correct the bad existing features and to promote higher standards in new developments.

The Town and Country Planning (Interim Control) Act 1959 was passed and came into effect. Its main purpose was to provide for control of development on the west and south coasts of the island (the tourist development areas) as well as the city of Bridgetown. Provision was also made to control development in the northeastern portion of the island which was and still is subject to erosion and landslides.

The Act was intended to remain in force for three years. During this time it was expected that more comprehensive and permanent legislation and perhaps, even a development plan would have been prepared. In fact, the interim legislation had to be extended and it was only in 1965 that a comprehensive Town and Country Planning Act passed the legislature. Even so, this Act, as amended, did not come into force until 1968. It provides the legislative framework for the present system.

A development plan prepared between 1964 and 1967 was published in 1970. It received final approval and came into effect officially in 1976. That plan was intended to cover the period 1965-85. Work on amending the plan was carried out between 1978 and 1981. The amended plan was published in April 1983 and towards the end of 1985 a public enquiry into the plan was held.

With regard to tourism the 1970 Physical Development Plan stated as follows:

"The brunt of demand for tourist accommodation will fall on whatever land is available that is contiguous with or adjacent to good safe bathing beaches. Primarily this means the region of the South and West Coasts of the island. Competition between permanent residents and tourists for these areas of high amenity has been resolved in favour of the dollar with the highest value. Other areas suitable for tourist development : rugged coastlines, old plantation great houses and yards have yet to be exploited. The problem of land availability for tourism will be resolved completely when it is fully appreciated that the balm of tropic sunshine is uniformly distributed over Barbados and that no habitable area is more than 30 minutes by good motorable road to a safe bathing beach. The provision of land for tourist accommodation is not a matter for serious concern in the land use economy of Barbados while close on 1000 acres of land which has been committed to tourist development at least three years ago remains undeveloped at this date."

The amended 1983 plan justified its revision of the above in these terms:

"The reason for omitting a number of areas from tourism development and for allocating them for other uses stems from the fact that the first plan over-estimated the rate of growth for tourism development and therefore all the allocated lands were not required. Consequently, in accordance with adjusted locational policy, tourism has expanded in a concentrated form along the prime beach areas rather than by scattering or dispersal to areas of secondary attraction value."

CURRENT SITUATION

In 1995 Barbados received 442,107 long stay visitors as well as 484,670 cruise ship arrivals. It is estimated that they spent U.S. $679.5 million.

In addition to the making of development plans there has evolved an elaborate system of control of land development through the making and determining of planning applications. In relation to tourism facilities this includes attention to matters such as location, siting, design, external appearance, height of buildings, density, sewerage and drainage, access, car parking and even landscaping.

Planning and development control in Barbados have now become rather complex and in the view of some developers and international funding agencies is stifling the development process.

There has quite naturally been a considerable increase in the number of applications for development made to the Town and Country Development Planning Office. The number of agencies to be consulted before a decision is made has also increased. In addition, all applications to do with the coastal area and all applications for major developments anywhere must now be referred to the Minister for decision. Before making a decision the Minister appoints a person or persons to conduct a hearing of the matter. Such applications can therefore take years to reach a decision.

The question therefore is whether or not planning and development control are achieving their purpose and if not what can be done to improve them.

In spite of any perceived shortcomings the planning system in Barbados works and is by and large achieving its objectives in shaping the pattern of land development in the country.

The Coastal Management Unit of the Ministry of Environment is one of the more recent institutions involved in the development control process. The Division works closely with Town and Country Planning on matters affecting the coastal area.

In other areas of concern such as sewerage, work is currently in progress to construct a mains sewer system for the south coast while a study is being done for the west coast. Construction has also begun on a new solid waste disposal site to serve the island.

In a few months a major project to overhaul the entire system of "Environmental Management and Land Use Planning for Sustainable Development" funded by the Interamerican Development Bank (IADB) will begin in Barbados. There are three elements to this project. These consist of:

1. Environmental Planning, Legislation and Management.
2. National Park System.
3. Land Use Policy and Planning.

The main objectives are:

(a) to establish national policy priorities for natural resource management, including guidelines and procedures for Environmental Impact Assessment of development actions in Barbados;

(b) to develop a framework for a comprehensive information system on natural resources;

(c) to formulate an environmentally sensitive framework and land use plan to govern land use development for the next ten years;

(d) to make recommendations for institutional strengthening of the Environmental Unit within the Ministry of Health and Environment and the Town and Country Planning Office, regarding staff requirements and needs, as well as for a training programme for staff from all agencies involved in environmental management.

These activities emanate from the evolving planning process. This project suggests that the government recognises the need for major adjustments to the management of the country's land resources and is prepared to do something about it.

It is also important to note that some attention is being paid to making use of modern technology in attempting to improve the system. The adoption of new technology however will not by itself bring about any desired change particularly in the absence of political will.

A WAY FORWARD

Geographic Information Systems (GIS) technology has reached Barbados and its use is beginning to spread like the proverbial wild fire. It may be an overstatement to say its use is spreading because there are systems in place but it cannot truly be said that they are being used and effectively so.

It is understood that there are systems in place at the following institutions:

- Coastal Management Unit
- Ministry of Agriculture
- Ministry of Transport and Works
- Ministry of Health (Environment Division)
- Ministry of Labour
- Ministry of Education
- Lands and Survey Department.

Computerised databases exist in many other departments and institutions of government such as Land Registry, Land Valuation and Town and Country Planning.

Experience has shown that the most problematic part of developing a GIS capability has been data conversion and data input. To make best use of this capability it would seem a good idea to aim for economy in this effort.

The way GIS is being introduced in Barbados and indeed in many other places is through separate projects in separate institutions with no working relationship with each other even though many of them must have recourse to the same information. Little attempt is being made to ensure the transferability of information across the various systems. Fortunately this is becoming less of a problem as many software developers are providing translators and other means for sharing information. There is also a need to develop certain standards and conventions for successful co-existence.

The Barbados Town and Country Planning Office does not yet have GIS. It is hoped that it will by the time the IADB project is completed. At present it has a computerised system for recording and tracking development applications. This information is of great value to many other institutions so ways must be found for accessing it.

The Coastal Management Unit is perhaps the most advanced institution in Barbados in its development and use of GIS. There is a good opportunity here for developing an "Integrated Framework for the Management of Beach Resources".

There is a good deal of socio-economic and spatial/land information that is common to coastal management and land planning. This would include (but is not limited to):

- population characteristics
- settlement structure
- topography
- climate
- environmentally sensitive areas
- coastal installations
- beach characteristics
- vegetation
- land use
- land values
- land ownership
- legal systems.

In the case of Barbados much of this information has been collected, converted to digital format and is being used by the Coastal Management Unit. It is expected that this information will be made available to Town Planning when required and there is no doubt that it will be. On the other hand Town Planning is a provider of information in the matters it deals with on a daily basis and the changes it makes to land by its decisions. In either case the information provided by one side is not always in a form that can be readily used by the other. This is apart from any differences in software programmes. There should therefore be prior consultation and co-operation to ensure greater useability.

Land planning operates on many levels. The first or strategic level is concerned, among other things, with determining areas most suitable for major urban expansion. Coastal area management, often regarded as a local area activity, has, in fact, an important role to play at the strategic level.

It is at this stage of land planning that constraints to major physical development are identified. Areas of concern are marked for exclusion. These include:

- areas too steep for development (erosion and sedimentation problems)
- forestry areas
- environmentally sensitive areas (wetlands, mangroves, wildlife habitats, national parks - terrestrial and marine)
- areas subject to tidal surges.

The need for major coastal installations - harbours and fishing ports, electrical generation facilities, beach facilities and other recreational accommodations must also be considered. There is great scope for land planning and coastal management to come together at this stage of the planning process in a mutually beneficial way.

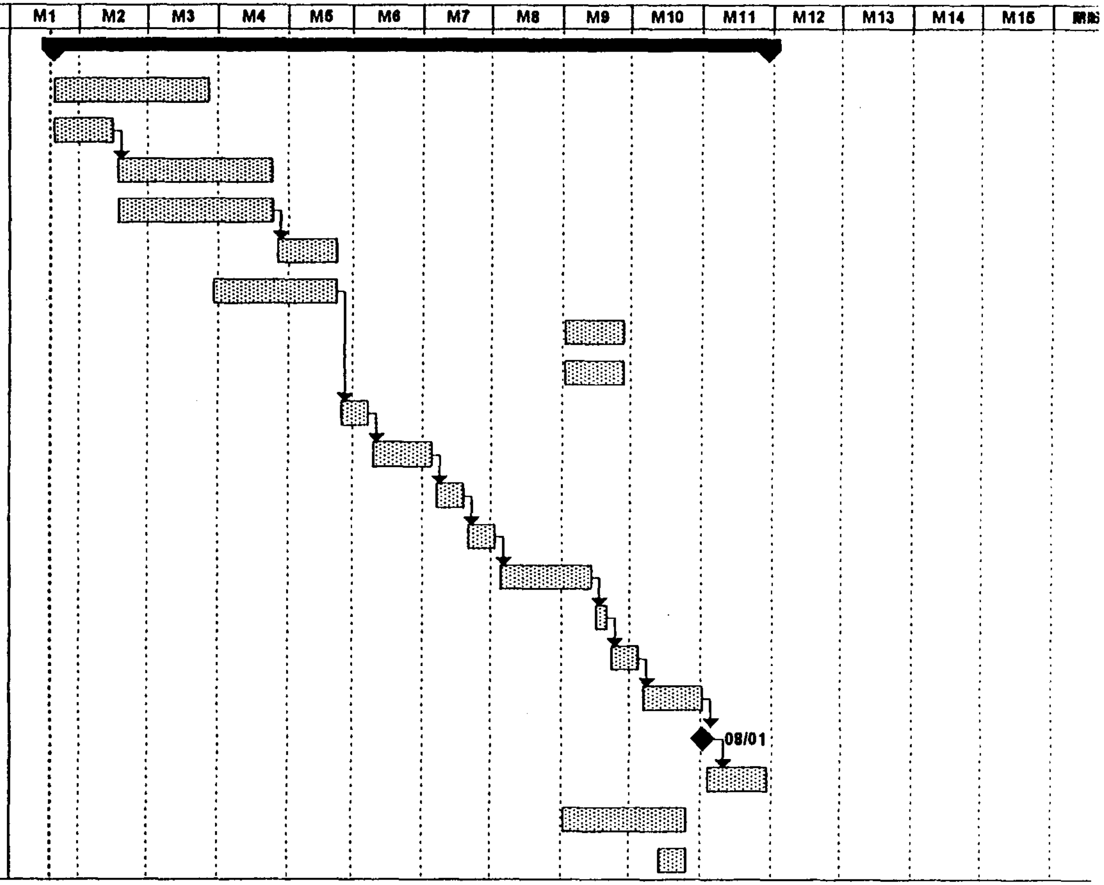
The attached Gantt Chart, Figure 1, was developed for a study in "Incorporation of Coastal and Marine Considerations into Physical Planning" with respect to Union Island in the state of St.Vincent and the Grenadines. It is offered for consideration here as a tool for building an Integrated Framework for the Management of Beach Resources in the Smaller Caribbean Islands.

If the collaborative effort is made at the planning level of the process the time spent in considering development applications could be considerably reduced and be limited to those matters which depart substantially from the approved plan.

CONCLUSIONS

Before the advent of international tourism there were no beach problems. Beaches came and went but there were no real problems of permanent beach erosion and serious threat to valuable property. Apart from traditional fishing, coastal and beach usage was limited to some occasional picnicking and seabathing. There were no real concerns of trespass on private property in gaining access to the coastline. As beaches were never overcrowded no social conflicts attributable to such cause ever arose. Pollution of beaches by liquid or solid waste did not exist.

ID	Task Name	Duration
1	Prepare Union Is.etc. Plan	226d
2	Define study area	10w
3	Develop integration methodology	4w
4	Assess environmental factors	10w
5	Assess development potential	10w
6	Determine development objectives	4w
7	Do supplemental surveys	8w
8	Assess human res.& infrastructure	4w
9	Assess legislation & institutions	4w
10	Assess development options	2w
11	Identify coastal man. options	4w
12	Public consultations	2w
13	Determine preferred options	2w
14	Draft dev. & coastal man.plan	6w
15	Present dev. & coastal man.plan	1w
16	Public consultations	2w
17	Revise plan	4w
18	Govt. adopts plan	0d
19	Publish plan	4w
20	Review EIS	8w
21	Train staff	2w



Project:
Date: 96/10/19

Task		Milestone	◆	Rolled Up Task		Rolled Up Progress	
Progress		Summary		Rolled Up Milestone ◇			

Page 1

Figure 1 Gantt Chart (Developed for Union Island, St. Vincent & the Grenadines)

Barbados has a long history of planning and development control but can by no means be said to have overcome all problems associated with beaches and tourism. The making and implementing of plans and the development application process must be capable of responding rapidly to constantly changing circumstances. The process is dynamic, like the coastline itself. The adoption of GIS technology can assist in providing the kind of rapid response that is being demanded.

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ISLAND BEACHES: NEW DIRECTIONS IN BEST MANAGEMENT PRACTICES

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ABSTRACT

Several newer categories of generic "Best Management Practices" (BMPs) for beach systems are discussed. These BMPs involve the identification, acquisition and use of new sources of information. These include a watershed management approach; a paired beach monitoring technology; the use of untapped historical data sources to provide "new" environmental baselines; the adaptation of risk assessment methodologies as a beach management tool. Several examples of beach management and analysis models which have worked elsewhere in the region are outlined.

INTRODUCTION

In the same way that a field or pasture cannot be"seen" in its entirety from within, neither can a beach. It is always a constructive tactic to back away from a single beach, whatever its problems, and examine the beach system within the context of its buffer zone/boundary conditions, adjacent biotic ecotones and abiotic inputs.

It is often useful, even essential, to characterize the full spectrum of inputs and outputs from both "upstream" (watershed) and "downstream" (oceanic) sources, treating both groups within a three dimensional context over time. How do they interact both on the beach and with the beach? Are there adverse aggregate or positive synergistic effects or both? What constitutes a healthy beach? An impoverished beach? A high risk beach? A problem beach? There are few simple solutions and beyond a nomenclature problem, one finds a variety of competing system and management models.

In the first place, however, the word "beach" lacks precision. A beach can be perceived as simply a biotic or abiotic ecotone separating and buffering land and sea areas. For some, a beach is a dynamic sand quarry, or a sandy recreational area or amenity. For others, it is a boundary for more valuable coastal "real estate". Still others see a fragile and resilient storm buffer and so on. It is a long list.

This paper seeks to address several newer categories of generic "Best Management Practices" (BMPs) for beach systems regarding the identification, acquisition and use of new sources and kinds of information about beach behavior drawn from unconventional locations.

BEST MANAGEMENT PRACTICES FOR BEACH SYSTEMS

Watershed Management Approach

Every beach is part of a watershed. This approach explores what can be learned using a watershed management approach which sees the beach principally as part of the coastal sediment sink and lower boundary at the base of the watershed. Inputs to the beach zone are evaluated, and key indicators monitored, especially run-off water quality and adjacent reef system health.

This is especially applicable where salt ponds or wetlands are found behind the beach berm. In this case the beach becomes a resilient, energy-buffering, sand filter separating the watershed and its wetland from the sea. This perspective drives a different set of questions and presents new management issues arising out of upland deforestation, land use, erosion and runoff management. It is concerned with reducing sediment and nutrient inputs and with potential flooding if beach berms are hardened (like levees) in any way, impounding flood waters, with or without pollutants, intentionally or otherwise.

In this case the beach offers some protection to coral reefs from land based sources of pollution. This is a reversal of the more traditional image of the reef as a protector of the beach. It also changes the list of stakeholders.

"Paired Beach" Monitoring

The tested classic "paired watershed" technology developed by the Environmental Protection Agency, is translated into a "paired beach" monitoring study evaluating the effectiveness of various management practices and indicators.

This involves simultaneous monitoring with a fixed protocol of developed and undeveloped beach sites, which are similar, to test the in situ effectiveness of selected management practices. The pairing accelerates the learning process as it facilitates the separation of natural and anthropogenic causes.

Historical Baselines

Previously untapped historical data can be developed, surrogate or retrospective, to provide environmental baselines for selected important or threatened beach sites over a longer time frame.

New techniques of finding, verifying and using the so called "old" environmental data from previously untapped sources e.g. university research team reports, student theses, dissertations, early external environmental impact assessments (EIA's), feasibility studies, aerial photographs, etc. make it possible to develop new "old" baselines. Once these are established, it is possible to carry out comparative resurveys and develop appropriate indicators to establish rates of change and other previously elusive dynamic characterizations regarding beach histories and modifications over time.

Risk Assessment Methodologies

Standard risk assessment methodologies can be adapted as beach management tools (including beach erosion, overwash and flooding contingency plans). Beach/reef/water ecosystem "health characterization" can be combined with risk assessment procedures to shape beach system monitoring regimes, establish preferred storm damage mitigation and prevention agendas leading to risk management priorities, remedial BMPs and worst case intervention schedules.

Application of Tested Management Models

Several management models which have been tested elsewhere in the region can be adapted and applied to beach systems. These include:

"Sediment Reduction Guidelines for Islands" which were developed for St. John in the U.S. Virgin Islands and are available from the United Nations Environment Programme's Regional Coordinating Unit in Jamaica.

"Dune Management" guidelines have been developed for Puerto Rico's Department of Natural Resources (DNR) by the Island Resources Foundation (IRF) and are available from DNR or IRF.

Dredge spoil island guidelines are available from the U.S. Army Corps of Engineers in a booklet entitled "Dredging is for the Birds."

Beach revegetation is covered in a new U.S. Department of Agriculture booklet entitled "Plants for Dunes."

A "model" for estimating erosion and sediment discharge from unpaved hillside roads, called ROADMOD, has been tested by the Virgin Islands Resource Management Co-operative on St. John and is more accurate than other models such as the USDE or RUSLE or TR55.

Model submerged artificial reefs for beach protection have been tested by the Barbados Coastal Zone Management Unit.

A simple pollution susceptibility model for embayments and beach areas which enables one to rank the risk at all bays and beaches around an island has been tested in several locations including the U.S. Virgin Islands, and is available from the IRF. The model relies principally on differences in calculated tidal flushing and the time required for dispersion and dilution.

CONCLUSION

These approaches, concepts and models provide new frameworks and methodologies with which to view beaches and their management. Many have been tested with some success in other parts of the region and information about them is freely available to innovative coastal managers.

PROTECTING OUR COASTAL RESOURCES: WHO WILL PAY THE FINANCIAL COST

David Simmons, Caribbean Tourism Organization, Barbados.

ABSTRACT

Two aspects of tourism related activity, sewage disposal and solid waste disposal, both of which have a significant impact on coastal resources, are discussed and strategies for their control are addressed. Sewage effluent is one of the most serious pollutants impacting the marine environment. Several countries have constructed central sewerage systems particularly in their high density tourist areas. The paper discusses various mechanisms for cost recovery of these very expensive systems. The volume of solid waste entering the marine environment poses serious threats to health and also adds to economic and aesthetic problems. The OECS waste management project, which seeks to upgrade and construct new facilities for solid waste disposal is discussed as well as several options for cost sharing. Recommendations are made for the regulatory authorities and the tourism industry.

INTRODUCTION

Over the past two decades we have been hearing a considerable amount about the impacts of tourism on beach resources and the extent to which continued unsustainable practices will result in the loss of beaches, a valuable ingredient of the tourism product being offered by the region. Many of these warnings have their origins in studies (Cambers, 1990; Hendry, 1992; Archer, 1993) which show a direct correlation between unplanned tourism development activities and a degradation of coastal resources including marine ecosystems. However, though it is relatively easy to point an accusing finger at the developer who is financing these tourism projects, tourism activities alone cannot account for all the degradation and destruction taking place along coastlines of individual countries.

In a United Nations Environment Programme report (UNEP, 1989) it was stated that:

> "The primary danger to the environment comes not from tourists, but from a flawed development process that must be accepted as the responsibility of the region's governments and private sector to correct. Institutional weakness with respect to comprehensive planning, project review, impact assessment and capital programming for supporting infrastructure need to be addressed as priority concerns of Governments, donor agencies and leading institutions".

When approached in this holistic manner, the role of tourism entities in ensuring the sustainability of beach resources is as critical as that of the planners and regulatory authorities. In this presentation we will focus on two features of tourism related activity which are having a significant impact on coastal resources and examine the strategies being employed to address them. These are the issue of liquid waste disposal from land-based tourism facilities and solid waste on Caribbean beaches.

SEWAGE DISPOSAL: IMPACT ON THE MARINE ENVIRONMENT

Sewage effluent is generally believed to be one of the most serious pollutants impacting on the marine environment (Vlugman, 1993; Ward & Singh, 1987; Gladfelter & Ogden, 1995). One of the major sources of that sewage effluent is the hotels and other land-based tourism establishments. These facilities are situated almost exclusively along the coastline and effluent disposal at sea, from treatment facilities operated by these hotels, is common throughout the region. This has been allowed to develop without the benefit of appropriate scientific data, fundamental to the proper design and siting of submarine outfalls, and inadequate monitoring of the operation of these treatment plants as well as the placement of these submarine outfalls. As a result there are instances where either partially treated or untreated hotel effluent are disposed of (a) in the immediate vicinity of the establishment, (b) in the bathing zone at locations treasured for their recreational value, and © in the vicinity of sensitive marine ecosystems (e.g: coral reefs, sea grass beds and mangroves).

In a study undertaken for the Caribbean Tourism Organization (Simmons, 1994), it was revealed that sewage and wastewater management practices in the Wider Caribbean region are inappropriate with a high percentage (80 - 90%) of that sewage generated by hotels being disposed of in the nearshore coastal waters without adequate treatment (Rodriguez, 1981; Reid, 1981; CEPPOL, 1991; Vlugman 1991).

Approximately half of the wastewater treatment facilities in the Eastern Caribbean are operated by hotels and resorts. These are largely of the pre-fabricated (packaged) secondary treatment plant variety. Primary and secondary sewage/wastewater treatment systems, as used by hotels, are of limited value with regards to microbial and nutrient removal. Inappropriate sewage treatment facilities result in millions of gallons of untreated fecal matter being discharged into the marine environment. This practice poses serious threats to tourists and locals who use the beaches for recreational purposes like swimming etc., and also impacts negatively on the marine environment. These adverse impacts are manifested by damage to coral reefs, seagrass beds and mangrove ecosystems, increased algal growth, coastal erosion, and a decline in nearshore fisheries.

Throughout the Caribbean, several countries have reported poor water quality at several of the recreational beach areas monitored, and even higher fecal coliform (FC) densities in marinas and harbours (CEHI 1985; 1986; 1989; 1991; 1993; Ward and Singh, 1987; Ward & Singh, 1992). On occasion, fecal coliform densities have been in excess of the maximum limit recommended as being safe for full body contact recreation under the proposed regional interim criterion (<200FC/100 ml of sample with no more than 10% of samples exceeding 400FC/100ml). Bacterial densities in excess of the maximum limit of the more lax water quality requirements of the EU (2000 FC/100 ml. sample) have on occasions been reported at recreational sites and more frequently in the marinas and harbours monitored (Simmons, 1994).

FC densities in excess of 200/100ml. are generally found in waters adjacent to point sources of sanitary significance (i.e. rivers, storm drains and sewer outfalls). At many of the recreational monitoring sites, effluent from hotel treatment facilities represents the single most important concern as a point source of fecal contamination.

RECENT TRENDS IN REGIONAL SEWAGE/WASTEWATER MANAGEMENT

In response to the problem of polluted coastal waters and in particular the poor quality of some popular recreational beaches, several countries (Barbados, Cayman Islands, Grenada, Jamaica and St. Lucia) have all invested heavily in the construction of central sewerage systems to facilitate the appropriate level of treatment and adequate disposal of sewage and wastewater from the hotels and other private establishments in critical coastal areas.

In Barbados, for example, the South Coast Sewerage Project, which should be commissioned within the next six months, has cost an estimated US$80m. The West Coast Sewerage Scheme for which plans are still be prepared, is estimated to cost US$100m. A similar project in St. Lucia which was commissioned in December 1995 cost the Government of St. Lucia US$9m. The Government of Jamaica has invested some US$41m for a central sewerage scheme for Negril and Montego Bay, and anticipate spending a further US$20m for a similar scheme for Ocho Rios. A similar sewerage scheme has also been commissioned in the Cayman Islands at a cost of US$10.5m, see Table 1.

A close analysis of the sewerage scheme in each of these countries will reveal that they are constructed in areas of high tourism concentration, a direct response to the perceived notion that the coastal waters in those areas were most at risk from sewage effluent emanating from the tourism establishments and other private and public buildings and households in the immediate vicinity. These systems, because hook-up is usually mandatory, are expected to relieve some of the environmental stresses on the coastal ecosystems, by redirecting that effluent into deeper waters offshore where tidal currents will take it away from shore and away from sensitive marine habitats. This system represents an improvement over current sewage/wastewater treatment and disposal practices of hotels and other private establishments.

The fundamental question for consideration is who will bear the responsibility of financing these developments. In St. Lucia, for example, the Government of St. Lucia bore the cost of constructing the project, but have plans to recover some of that cost through a mandatory hook up of all the hotels and tourism establishments in the area as well as other households withing a half mile radius of the sewer line. In Barbados, for example, it is proposed that all the hotels and tourism establishments on the south coast of Barbados as well as households up to the 6m contour or approximately 400 m distance from the sewer line will be hooked up to the sewerage system in order to allow the government to recover the cost of the system.

Table 1 Cost of Sewerage Systems in Select Caribbean Countries

COUNTRY	COST(US$) Millions
Barbados - South Coast - West Coast	 80 100 (est)
Jamaica - Negril - Montego Bay	 20 21
St. Lucia - Rodney Bay	 9.0
Cayman Islands	10.5

It is estimated that approximately 3000 households and business establishments will be hooked up to this sewerage system. The cost recovery mechanism being proposed will involve commercial establishments paying higher rates as part of their monthly water bills. It is also proposed that households hooked up to the system will have high water bills based on the amount of water used as registered on their water meters. Revenues from households and other commercial entities represent only 30% of the cost of the system. It is being proposed that the other 70% will be met through increased taxes distributed across the tax paying public. The rationale for this thinking is that the coastal resources are part of the national patrimony and the whole economy benefits from maintaining this resource in a pristine manner.

If, as has been established, tourists use 1.5 times more water than the general public the question is why are they are not asked to pay a larger share of cost of the sewerage system? First of all, commercial establishments pay higher rates of water use. Secondly, the tourism industry is heavily taxed. In view of declining revenue per room in the tourism industry in the Caribbean, some will argue that it is not in the best interest of the region that more taxes should be levied on hotels.

Another point which should be considered is that the hotels and other tourism establishments which are hooked up to the central sewerage system will realize savings as a result of not having to make initial costly outlays on individual treatment plants and other facilities for treating their sewage. They are also expected to realise savings as a result of lower maintenance costs as it is well established that these packaged treatment plants, commonly found at hotels and other tourism establishments have high maintenance costs. A strong case can be made for some of these savings to be passed on to the authorities responsible for the operation of the central sewerage system.

IMPACT OF SOLID WASTE ON THE MARINE ENVIRONMENT

The volume of solid waste entering the marine environment posed a serious threat both to the marine and terrestrial environment. The impact of solid waste on the marine environment ranges from that which impacts on marine ecosystems, to that which washes up on shores of the Wider Caribbean and impacts on human health and causes aesthetic and economic problems for the islands. Some of these impacts are as follows:

(a) Impact on Flora and Fauna

It is estimated that plastics constitute some 60% of the debris entering the marine environment. These products degrade slowly and remain suspended at the sea surface, or sink to the bottom and remain there for a long time. The accumulation of this debris poses significant threats to marine mammals, seabirds, turtles, fish and crustaceans. Ingested plastics cause death via starvation. Also, animals become entangled in loops or openings of floating debris and may drown.

(b) Physical Degradation

The large input and slow degradation of plastics and other marine debris leads to an accumulation of unsightly garbage on many coves and beaches. Metals and glass, when disposed of near reef systems, can also lead to an accumulation of garbage on those reefs and even lead to their destruction.

(c) Aesthetics and Economics

The presence of garbage on beaches is unsightly, particularly in areas where the tourism product is highly dependent on a reputation for beautiful beaches and healthy ecosystems. An increase in the accumulation of marine debris could decrease the beauty of these beaches and consequently lead to a decrease in the number of visitors and beach users. This translates into lost revenue for hotels and to the tourism industry in general.

Marine debris also poses a problem for commercial and recreational fishing. Debris may foul or damage fishing gear and boats which are costly to repair and or replace. This translates into lost income for fishermen and boat operators.

(d) Health

Bottles, glass and metal containers which wash up on the beach can pose a threat to bathers and other beach users who may accidentally cut or otherwise injure themselves. The contents of these containers could cause serious health problems if skin contact is made or if accidentally ingested. In addition, the health impact of medical waste represents a real threat if improperly or inadvertently handled by a beach user.

Every year the Center for Marine Conservation together with several other regional and local organizations embark upon the International Voluntary Beach Cleanup. Table 2 provides some indication of the amount of garbage collected at several beaches in a number of Caribbean countries during this international cleanup initiative in 1994.

In 1994 several Caribbean countries participated in this international programme. In 1996, as part of the International Coastal Cleanup Day 1996, volunteers collected even more garbage from several of the popular beaches in Barbados. At Carlisle Bay, 55 divers and 10 snorkelers retrieved 476.28 kg of garbage from the ocean floor. At Long Beach, 110 volunteers collected 942 kg of garbage and at Cattlewash, St. Andrew 115 volunteers collected some 658 kg of garbage.

Because these beach cleanups occur once a year, they provide only a spotlight of the magnitude of the problem. Based on analysis of waste collected on these beaches, several sources, namely beach goers, recreational fishing and boating, domestic waste, commercial fishing, sewer systems, commercial shipping, offshore oil and gas and research and military vessels, have been identified as the contributors. In the Caribbean, "beachgoer debris and litter carried by wind, runoff and streams were the most significant contributors at almost all sampled beaches" (North Carolina Sea Grant Program, 1995). Essentially, debris left by beach goers and from other land based sources accounted for most of the debris found on Caribbean beaches.

The problem of garbage on popular bathing beaches, together with the recognition that land-based pollution may be the source, have given rise to greater awareness of the inadequacy of existing facilities for managing and disposing of solid waste.

Table 2 International Coastal Cleanup Results for Selected Caribbean Countries

Country	No. Of Volunteers	Debris Kg	Pounds	Kilometers	Miles
Bahamas	348	2,236	4,926	16.6	10.5
Barbados	20	82	180	1.6	1
Belize	580	1,816	4,000	29	18
Bermuda	250	4,450	10,000	32	20
Cayman Islands	136	4,958	10,920	22	14
Grenada	300	1,816	4,000	16	10
Jamaica	459	3,598	7,925	6	4
St. Kitts & Nevis	194	1,318	2,902	3	2
St. Vincent & the Grenadines	250	4,540	10,000	10	6
Turks & Caicos	30	524	1,154	3	2

Marine Debris WORLDWIDE, 1995

Under the Organisation of Eastern Caribbean States (OECS)/World Bank Waste Management Project, several of the OECS countries have agreed to upgrade and construct new facilities for managing and disposing of both ship-generated and land based solid waste.

In order to justify the OECS Waste Management Project it was argued that cruise ships were a major contributor to the problem of garbage washing up on Caribbean beaches. The project was therefore conceived as a means for addressing the problem of ship-generated waste while also providing facilities for accommodating the land-based waste disposal problem.

The OECS Waste Management Project will support and provide for five principal programmes. These are:

(a) Construction of new sanitary landfills, or the upgrading of existing landfills.

(b) A system of waste collection and disposal for MARPOL Annex V wastes.

(c) Enhancement of waste collection including, where appropriate, development of transfer stations, and provision of equipment.

(d) Waste minimization/recycling through analysis of policy measures needed for encouraging waste minimization.

(e) Institutional strengthening including development of legislation on solid waste and environmental health, as well as public education programmes.

The fact is that cruise ships do not contribute as much to marine pollution as once thought (Simmons, 1994). In fact, very few of the cruise ships have any need to dispose of waste at ports of call in the OECS countries. However, by couching the problems of waste management in a manner which made it appear that ship-generated waste was a major contributor to pollution of our beaches, not only did it provide the justification for the construction of facilities for receiving ship-generated waste, but it also provided a source for recovering the cost of investment in land based waste disposal infrastructure.

The cost of these facilities are estimated to cost in the region of US$5m - US$7m. However, it has been determined that these countries should be able to recover their investment cost through the imposition of a head tax and an increase in municipal taxes. The cruise industry have already indicated their willingness to pay their fair share of tax to cover the cost of collecting and disposing of their ship-generated waste. It is therefore not anticipated that there will be much difficulty in recovering the cost of constructing and establishing new facilities for waste management. The only issue for debate may likely be "What is a fair share" of the cost of disposing of ship-generated waste?

In this current climate of expenditure on facilities to protect and preserve our beach resources, the question of cost recovery is very relevant. However, sufficient thought has not accompanied these ventures. What is the role of tourism establishments in helping to support these cost recovery measures? Are hotel and tourism establishments the primary beneficiaries? If they are, what portion of the cost should they be asked to absorb? As new thinking emerges regarding the value of our beach resources and its importance to tourism, it is inevitable that there will be more calls for tourism establishments to bear a greater portion of the cost. As stated earlier, that thinking is fraught with difficulty since measuring the benefits may not be a simple and straight forward matter. Also, it may be argued that the benefits provided by the coastal resources are indeed enjoyed by the entire community and that the community as a whole should contribute to the maintenance of this pristine environment.

At the same time it is counter productive for tourism establishments, who undoubtedly contribute to the pollution of the marine environment, to expect that governments will always be expected to take a lead role in devising measures to mitigate the impact of destructive practices.

Tourism establishments must become more proactive in devising approaches to minimising the amount of pollutants being disposed in the marine environment. They must undertake guest sensitization and educational awareness programmes to inform guests of the need to minimise waste. Most important, they must recognize that there is a cost to pollution and that under the polluter pays principle, they must take greater responsibility for their contributory role in polluting the marine environment.

Like the central sewerage schemes designed to minimise the pollution of the pristine marine environment, the upgrading and construction of new facilities are going to impose a financial burden on the governments of the participating countries.

Recognizing that the sustainable use of beach resources is both the responsibility of planning and regulatory authorities as well as the responsibility of those in the tourism industry, there is need for greater monitoring by the planning and regulatory authorities as well as better monitoring of the operations of the hotels and other tourism establishments. In this context a set of recommendations have been outlined below, which if followed, will enhance the capacity of those involved to achieve greater results in their individual areas as they relate to the sustainable use of beach resources.

RECOMMENDATIONS

(a) Concerted efforts should be made to improve national monitoring programmes particularly with regards to treatment plant inspections, effluent and coastal sanitary water quality monitoring.

(b) Training of public health inspectors and laboratory personnel in the respective inspection and analytical procedures should be undertaken to facilitate the implementation of the monitoring and enforcement mandate of the Ministries of Health.

(c) Control of the proliferation of packaged plants in the hotel sector should be implemented through the development of centralised sewage treatment and disposal systems and/or the promotion of alternative low technology systems which offer greater environmental protection.

(d) National/regional legislation should be developed and enforced with a sharp focus on the protection of coastal environmental resources.

Hotel/Tourism Sector

(a) Effluent disposal in the immediate recreational area and in the vicinity of coastal ecosystems should be restricted or prohibited. Construction of longer submarine outfalls at locations which allow for the maximum speed of offshore effluent dilution and dispersion should be urgently considered.

(b) Hotels and other tourism establishments should be made aware of the regional/national environmental and waste management criteria (either programmed or enacted) and employ appropriate self-regulatory measures within the industry to meet their requirements.

(c) Codes of environmental practice should be developed, which recognise the importance of the coastal resources to the survival of the tourism industry and to the regional economy.

(d) Sewage/wastewater reduction and recycling schemes should be implemented.

(e) Link-ups with established central sewerage systems should be encouraged and promoted within the industry.

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E. REGIONAL INITIATIVES IN COASTAL RESOURCES MANAGEMENT

THE ROLE OF THE OECS NATURAL RESOURCES MANAGEMENT UNIT IN COASTAL ZONE MANAGEMENT

Patricia Phillip,
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ABSTRACT

This paper provides an insight into the work of the OECS Natural Resources Management Unit in the area of marine and coastal resources management. It illustrates the fact that regional institutions have to be flexible enough to adjust their modus operandi, if necessary, to assist countries in addressing their increasingly complex environmental problems. The NRMU's Coastal Resources Management Initiative (CRMI) is also discussed as well as how this has been translated into a framework for the adoption of an Island System Management approach to resource use in the OECS sub-region.

INTRODUCTION

The aim of this paper is not merely to provide an insight into the work of the OECS Natural Resources Management Unit (OECS-NRMU) with respect to coastal resource management but more importantly, to illustrate the fact that regional institutions have to be flexible enough to adjust their *modus operandi*, if necessary, to assist countries in addressing their increasingly complex environmental problems.

BACKGROUND

Over the past ten years, the NRMU has become increasingly active in promoting coastal resources management in the sub-region. This is in recognition of the importance of the coastal zones of Member States to their development. It is fairly well accepted that the coastal zone and its resources are the quintessence of the islands' identities. The mix of activities which occur within this geographic area has given rise to conflicting land use and degradation of resources. It is not surprising therefore, that many of the OECS Member States are now having to deal with problems related to coastal erosion, pollution of reefs and coastal waters and high levels of coastal damage from natural disasters. These problems have been further compounded by inadequate and weak management systems and strategies.

The first contributions of the OECS-NRMU to coastal zone management in the sub-region were with respect to the preparation of tools aimed at increasing national capacities to better manage their coastal resources. Specifically, these tools relate to beach monitoring, mangrove management and legislation. Two beach monitoring manuals were developed, the first of which, entitled "Beach Monitoring", sets out step-by-step procedures on how to establish a monitoring system and is essentially designed as a working document for use both in the field and office. The second manual "Lecture Notes on Beach Changes and their Measurement" outlines in a simple format the physical and oceanographic background to beach changes. The manual on "Administrative Procedure for Mangrove Management" sets out procedures to be followed in developing a mangrove area management programme in the Caribbean. It is user friendly and is specially designed for use by non-specialists. A Harmonized Draft Frame Coast Management Act and Regulations was also developed by the NRMU in collaboration with Member States. It contains regulations pertinent to a wide range of ecosystems such as coral reefs, seagrass beds and beaches.

Over time, it became clear to the NRMU that these tools were not being effectively utilized within the Member States and that coastal resource degradation was worsening. This spurred the NRMU to undertake an assessment of problem issues in Member States particularly with respect to the processes and interactions which occur in the coastal zones. The aim of this assessment was to provide the Unit with current information to develop a framework for integrated coastal zone management in the OECS sub-region.

The major issues identified in the assessment were as follows:

1. Increased pollution resulting from accelerated urbanization, tourism and agricultural activities*.
2. Accelerated unplanned development impacting on critical habitats*.
3. Indiscriminate use of resources resulting in the loss of productivity.
4. Unregulated removal of sand and vegetation from shores resulting in increased rates of erosion of shorelines.
5. Inadequate and improper shoreline engineering works resulting in accelerated erosion.
6. Absence of standardized requirements for environmental impact assessments.
7. Lack of comprehensive development control guidelines and policies: weak planning mechanisms.
8. Lack of inter-sectoral coordination resulting in inadequate management of island resources.
9. Lack of awareness with respect to the interaction between resources e.g. relationships between shore-based activities and coastal resources.

* These were identified by all respondents as being the main problems facing coastal zone management in the OECS sub-region.

This list of issues demonstrates two major facets of CZM issues in the OECS, these are:

1. The adverse effects of a wide array of different forms of poorly planned and managed development in upland and marine areas on the sustainable use of coastal ecosystems;

2. The intersectoral nature of development issues where different interest groups may be suffering common problems as a result of poorly planned and managed activities of other interest groups.

This suggests that the resolution of individual coastal issues will require the adoption of management boundaries which encompass the major development activities and their environmental linkages with coastal areas and activities. This prompted the NRMU to adopt an Island Systems Management (ISM) approach to resource management since it recognizes the inter-relationships between ecosystems. The ISM approach is defined by Chase and Nichols (OECS-NRMU, 1994) as "a multi-disciplinary, multi-sectoral, multi-faceted mechanism aimed at rationalizing the use of island resources and the achievement of the goals of sustainable development". ISM is described as an adaptive management strategy which addresses the issue of resource use conflicts and which provides the necessary policy orientation to control the impacts of human intervention on physical environments.

THE BIRTH OF THE COASTAL RESOURCES MANAGEMENT INITIATIVE

In December, 1994, the NRMU in collaboration with the United Nations Development Programme (UNDP) and the United Nations Centre for Human Settlements (UNCHS) convened a regional workshop on integrated coastal zone management (ICZM). The aim of this workshop was to provide an opportunity for Member States to discuss strategies for strengthening ICZM within the context of the assessment. There was broad sector representation at the workshop which is critical to any discussion on coastal zone management. The NRMU was requested by participants to further develop the concept of ICZM and translate it into an action plan leading to the development of a regional project.

In accordance with the recommendations of the meeting, the NRMU staff with technical support from selected Member States, UNDP, UNCHS, the Caribbean Environmental Health Institute (CEHI) and the World Wide Fund for Nature (WWF) met in early 1995 to begin to conceptualize the Coastal Zone Management Initiative. After much debate, it was agreed that the term "coastal resources" would be utilized as opposed to the term "coastal zone". The principal justification for the use of this term stems from the ISM philosophy in which the entire island system is viewed as a coastal zone. In this case, therefore, it was necessary to differentiate between the coastal zone and coastal resources. Implicit in the CRMI is the fact that the management of coastal resources should be seen as an integral part of a broader framework of integrated development planning and management at the local, national and regional levels.

The central problem which the CRMI attempts to address is "Ineffective Policy Mechanisms for Inter-Agency Collaboration." This arose primarily as a result of:

- Limited public awareness and therefore advocacy on coastal resource management issues;

- Lack of inter-agency and inter-sectoral collaboration;
- Lack of donor coordination;
- Structural weaknesses in the OECS-NRMU.

These factors have led to the concept that the CRMI should focus on:

1. Developing a mechanism for inter-agency collaboration at national and regional levels;
2. Ensuring that donor funding, technical assistance and regional expertise are used to create maximum benefit;
3. Strengthening the OECS-NRMU to become the lead facilitating agency for CRM in the OECS sub-region.

The overall goal of the CRMI is "to achieve sustainable economic development for natural resources through integrated coastal resources management." The following are the targets of the CRMI:

1. Management, administrative, legislative and technical capacities for ICRM at the national level improved;
2. Coordination of ICRM activities among agencies/organizations at the national and sub-regional levels improved;
3. Knowledge and understanding of the integrated nature of CRM issues and problems increased at all levels;
4. Selected CRM issues/problems addressed or alleviated;
5. Member States assisted in the development/implementation of policies which facilitate sustainable use of coastal resources.

THE CRMI: A FRAMEWORK FOR THE ADOPTION OF THE ISLAND SYSTEM MANAGEMENT APPROACH TO RESOURCE MANAGEMENT

The CRMI and its implications for the NRMU hastened the holding of a strategic review of the NRMU in April 1995, the culmination of which was the development of a Strategic Plan for the Unit to the year 2000. Six broad programme areas were identified including ICRM. In January 1996, the Fisheries Unit of the OECS was merged with the NRMU thus expanding the mandate of the Unit to include the planning and implementation of fisheries programmes. It was evident that the fisheries programme lent itself to inclusion within the CRMI. With assistance from the British Development Division in the Caribbean (BDDC), the NRMU in March 1996, embarked on the development of an implementation plan for promoting the CRMI. A consultant from the Commonwealth Fund for Technical Cooperation (CFTC) was also providing assistance to the Unit at that time in reviewing its Strategic Plan and advising on the institutional requirements for shifting the Unit's focus from environmental management to sustainable development. This shift was deemed necessary to accommodate the new fisheries portfolio of the Unit.

Throughout this process, it was evident that all the programme areas which had been identified in the Strategic Plan were in fact intrinsically linked to the CRMI. The relationship between the CRMI and fisheries, parks and protected areas, watershed development and environmental planning for instance could not be denied. This resulted in the NRMU adopting CRM as the central programme framework which encapsulated the other thematic areas. The CRMI has therefore now been translated into a regional framework for the adoption of the ISM philosophy. The activities identified within the CRMI Plan of Action are now incorporated into all the elements of the NRMU's Five Year Operational Plan.

SELECTED OECS-NRMU CRM ACTIVITIES

Progress with the implementation of the CRMI Plan of Action has taken place fairly rapidly since the adoption of the Initiative by the NRMU's Technical Advisory Committee (TAC) and the OECS Authority in mid 1995. The following are some of the activities which have been undertaken within the context of the CRMI:

- National Focal Points (NFPs) have been established in each Member State. Their roles are principally to (1) disseminate information on CRM issues from the regional to the national level; (2) facilitate the establishment of an inter-sectoral coordinating mechanism for CRM at the national level; (3) provide in-country logistical support to NRMU's CRM consultants.

- An inter-sectoral coordinating committee has been launched in four Member States. It is intended that these committees will function as a coordinating body for all environmental matters at the national level. The NFP will, however, remain as the link between the regional and national CRM activities.

- A regional assessment of the status of planned and on-going CRM activities in Member States was undertaken by a two person team in March and April, 1996. The aim of the assessment was to achieve more systematic and coordinated planning and implementation of CRM in Member States. Field trips were conducted to stressed sites, interviews and questionnaire surveys administered and consultations held with concerned parties in private, public and NGO sectors. Preliminary findings indicate that:

1. Coastal resources are considered very important to national development;
2. There are many uncoordinated activities, such as uncontrolled and untreated liquid waste discharges, impacting on the environment and leading to environmental stress;
3. The response to these stresses is for the most part uncoordinated and disjointed;
4. The NGO sector in almost all the Member States is strong but they are constrained by a lack of technical expertise and financial resources;
5. There is no strong partnership arrangement between government and the private/NGO sectors;

6. There is no overall authority or frame legislation for environmental management except in St. Kitts Nevis;
7. There is, however, sectoral legislation, although most of this legislation tends to be dated;
8. There are generally inadequate manpower resources to allow government agencies to fulfill their responsibilities under their legal mandate;
9. Environmental impact assessment is still not yet a legal requirement in most of the Member States.

- The NRMU is now in the process of assisting selected Member States with the preparation of National Action Plans for the management of beaches and mangroves. The aim of these plans is to establish a management mechanism aimed at ensuring the sustainable use of these ecosystems. It is intended that these plans will be effected through a system which will ensure the utilization of the CRM tools which have been alluded to earlier in this paper, and the development of an efficient system of management which will be characterized by greater collaboration between stakeholders. Components of the plans are, however, articulated by Member States through national consultations. National sub-committees for the management of beaches and mangals have been established in those participating countries.

- The Unit is also currently engaged in developing an awareness campaign on the management and use of coastal resources. A poster has been developed and distributed through the sub-region. This will be accompanied by a multi-media campaign, elements of which will include:

1. sub-regional interactive call-in programmes;
2. public service announcements;
3. community based consultations and animation programmes.

- The Unit continues to function as a facilitator, together with the Caribbean Conservation Association (CCA) for the Caribbean Marine Parks and Protected Areas Managers Network. The Organization of American States (OAS) has agreed in principle to fund a project on parks and protected areas, an important component of which will be developed as tools for coastal and marine resource management.

- The NRMU responds to individual requests from Member States. Assistance is presently being provided to the Government of St. Vincent & the Grenadines with respect to the development of a coastal conservation programme for selected islands of the Grenadines and southern St. Vincent. A study has been completed of the sites with technical assistance from the Coastal Zone Management Unit of Barbados. On acceptance of the recommendations of the report by the Government of St. Vincent & the Grenadines, the NRMU will seek funding from the InterAmerican Development Bank for mitigative action in the sites.

- The Unit will soon be embarking on the preparation of coastal atlases for Member States. With funding provided from the BDDC, the NRMU will be starting a two phased regional programme on coastal inventories for the Eastern Caribbean. Phase 1 will involve carrying out a survey of the Grenadines using a team of consultants. Phase 2 will be dependent on the success of the Grenadines work and will involve funding the extension of the techniques to other Member States, under NRMU supervision and using primarily regional expertise.

- Apart from these activities, the Unit will be assisting Member States in developing and implementing catalytic national level projects. Funds provided by the BDDC will permit NRMU to develop a suite of small scale projects to be implemented by national and other sub-regional agencies.

- As a teaching tool for ISM, the NRMU is currently developing a video to show the multi-disciplinary, multi-sectoral and multi-faceted nature of the management of natural resources.

CONCLUSION

CRM is therefore synonymous with the work of the NRMU. The NRMU operates within an ISM framework and consequently all the activities being implemented by the Unit impact in some way on coastal and marine resources. The achievement of the sustainable use of coastal resources is therefore not a simple task. It is, however, not impossible. We all need to work together as partners in the process recognizing that our activities, in one way or another, impact on our coastal and marine resources.

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CARIBBEAN: PLANNING FOR ADAPTATION TO GLOBAL CLIMATE CHANGE PROJECT (CPACC)

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ABSTRACT

The project entitled Caribbean Planning for Adaptation to Climate Change (CPACC) was initiated at the request of the small island developing states of the Caribbean at the SIDS conference in May, 1994. The overall objective is to assist the countries to prepare to cope with the adverse effects of global climate change. The project has two main components: adaptation planning and capacity building. The project is scheduled to start early in 1997.

BACKGROUND

The Caribbean countries, like other small island and coastal areas, face difficult decisions in confronting the adverse effects of global climate change and associated sea level rise. The costs of adapting to a rise in sea level could be very large compared to the size of the economies of these small developing countries island.

The preliminary Coastal Zone Management Studies of the Intergovernmental Panel for Climate Change (IPCC) indicated that the need to implement strategies to cope with sea level rise is more urgent than previously thought. Natural systems which help protect marine and coastal resources are already being degraded by anthropogenic activities. Mangroves, which buffer the land from storm surges and the sea from land-based sources of pollution, are being depleted. Uncontrolled or ill-conceived development schemes, over-exploitation of living marine resources, and impacts related to urbanization, tourism, and agriculture all contribute to decreased resilience of coastal and marine ecosystems. As a consequence, the future vulnerability of coastal resources and infrastructure to sea level rise increases constantly, underscoring the urgent need for an integrated framework for addressing these issues. The difficulties are compounded by the insufficient data and lack of either suitable information systems or a coordinated institutional structure to managing coastal and marine resources.

Present stress on coastal resources could be further impacted by projected increases of sea level as a direct consequence of global warming. The Caribbean islands are particularly vulnerable to sea level rise, which is likely to affect freshwater supply and increase beach and coastal erosion and the impact of tropical storms. Since population and economic activities are concentrated in the coastal zone, sea level rise threatens a disproportionate share of industrial, tourism, energy, transport and communications infrastructure. Thus, there is a need for measures to reduce vulnerability.

The IPCC has calculated first order costs for protection of Caribbean shorelines from future sea level rise, including low coasts, cities, harbors, island elevation, and beach nourishment. Estimates exclude costs for unprotected dry lands, ecosystems that may not be lost, and the impact of saline intrusion and increased storm frequency. With respect to Caribbean island territories, the projected cost of new construction alone is US$11 billion, which is well beyond the combined investment capacity of their economies. Other more cost-effective adaptation measures are therefore needed.

LEGAL FRAMEWORK

Global concerns about climate change and its repercussions prompted the international community to begin negotiating a Framework Convention on Climate Change (FCCC) in 1991. The Convention establishes a legal framework for responding to global climate change through the promotion of measures aimed at mitigating emissions of GHG and preparing for adaptation to the adverse effects of climate change. The FCCC agreed that adaptation to these adverse effects will require short, medium, and long-term strategies which should be cost effective, should take into account important socio-economic implications, and should be implemented on a stage-by-stage basis in developing countries that are Parties to the Convention. The sequence of activities are presented in Table 1.

Table 1 Sequence of Activities

Stage I	Planning, including studies of possible impacts of climate change to identify particularly vulnerable countries or regions and policy options for adaptation and appropriate capacity building
Stage II	Measures, including further capacity building, which may be taken to prepare for adaptation
Stage III	Measures to facilitate adaptation

Furthermore, the FCCC agreed that for the Stage I the Conference of the Parties would entrust the Global Environmental Facility(GEF) to meet the agreed costs of the required activities The FCCC has been ratified by most Caribbean countries. More significantly, the Caribbean region, along with other small island and low-lying states, has been effective in drawing the attention of the international community to the potential adverse impacts of climate change on their economies. The region has also been active in the work of the IPCC, including the Coastal Zone Management Subgroup of the Response Strategies Working group.

PROJECT ORIGIN

The Caribbean: Planning for Adaptation to Climate Change Project has its origin in the Global Conference on the Sustainable Development of mall Island Developing States which took place in Barbados in April/May 1994. During this conference the small island developing states of the Caribbean requested OAS assistance in developing a project on adaptation to climate change for submission to the GEF. The project was submitted for consideration of the GEF endorsed by CARICOM's Ministers of Foreign Affairs. Participating counties are listed below:

Antigua and Barbuda
Bahamas
Barbados
Belize
Commonwealth of Dominica
Grenada
Guyana
Jamaica
St. Kitts and Nevis
St. Lucia
Trinidad and Tobago.

The GEF Council approved the project as part of its Work Program in May, 1995, with the World Bank as its implementing agency. The countries and CARICOM have maintained an active level of participation throughout the project preparation phase. A Project National Focal Point (NFP) has been designated for each country.

THE PROJECT

Objectives

The project's overall objective is to support Caribbean countries in preparing to cope with the adverse effects of global climate change (GCC), particularly sea-level rise, in coastal and marine areas through vulnerability assessment, adaptation planning, and capacity building linked to adaptation planning. More specific objectives are listed below.

(I) strengthen the regional capability for monitoring and analyzing climate and sea level dynamics and trends, seeking to determine the immediate and potential impacts of GCC;

(ii) identify areas particularly vulnerable to the adverse effects of climate change and sea level rise;

(iii) develop an integrated management and planning framework for cost-effective response and adaptation to the impacts of GCC on coastal and marine areas;

(iv) enhance regional and national capabilities for preparing for the advent of GCC through institutional strengthening and human resource development; and

(v) identify and assess policy options and instruments that may help initiate he implementation of a long-term program of adaptation to GCC in vulnerable coastal areas.

DESCRIPTION

The project would follow a regional approach; it would be executed through the cooperative effort of all eleven participating countries and through a combination of national pilot/demonstration actions and regional training and technology transfer linked to adaptation planning. This approach seeks to strengthen regional cooperation and institutions, and to provide cost-effective means for adaptation planning, data collection, and sharing of information, skills and project benefits. The project would seek to build on existing institutions and experiences, and to liaise with other important regional initiatives and programs underway in the Caribbean. It would consist essentially of enabling activities, complemented by selective capacity-building activities, aimed at creating or strengthening endogenous conditions and capabilities necessary to prepare a long-term program for adaptation to GCC. Project execution would take four years involving two components: adaptation planning and capacity building.

COMPONENTS

(I) Adaptation Planning: short-term planning for adaptation to GCC in vulnerable areas. It focuses on regional sea/climate data collection and management, impact and vulnerability studies, and assessment of policy options. Throughout this component, the project would execute a comprehensive program of human resource development for upgrading skills of technicians and officials from participating countries in areas relevant to GCC and adaptation planning. Sub-components are described in Table 2.

(II) Capacity Building: would focus on strengthening the capacity of the participating countries to carry out GCC adaptation planning. All participating countries would be assessed to better build their national capacity to implement project activities and to ensure their continuation after completion. Activities under this sub-component include:

(i) establishment of a Regional Project Implementation Unit (RPIU) responsible for project coordination at the regional level and for providing basic technical support and supervision in the key technical areas of the project;

Table 2 Sub-components of Component I: Adaptation Planning

Sub-Component	Objectives	Participating Countries	Responsible Institutions
(i) Design and Establishment of Sea Level/Climate Monitoring Network (Regional)	The sea level/climate observation network (18 gauges) proposed for installation in each of the eleven participating countries would include a standardized set of instruments to measure water level, vertical land motion, air and sea temperature, wind velocity, precipitation, and other site-specific ancillary variables. The Caribbean Meteorological Institute would be the lead regional agency.	Regional	Regional and national meteorological agencies
(ii) Establishment of Databases and Information Systems (Regional)	These data bases and information systems would allow key regional and national institutions to acquire, analyze, store, and disseminate data on climate change and its impact on natural and manmade systems.	Regional	Environment and Planning Ministries
(iii) Inventory of Coastal Resources and Use (Regional)	To further develop each participating country's inventory of coastal resources so as to provide the necessary baseline data for the execution of other project activities.	Regional	Environment and Planning Ministries
(iv) Design and Establishment of Coral Reef Monitoring Network (Pilot)	To increase existing knowledge about the extent and sources of coral reef degradation through the establishment of long-term coral reef monitoring programs which over time would show the effects of global warming factors.	• Bahamas • Belize • Jamaica	Coastal Zone Management and Environment agencies
(v) Coastal vulnerability and risk assessment (Pilot)	The IPCC coastal vulnerability assessment "common methodology" model will be reviewed and modified for the application to the Caribbean region.	• Barbados • Grenada • Guyana	Ministries of Planning, Environment and Agriculture
(vi) Formulation of a Policy Framework for Integrated Coastal and Marine Management (Regional)	To support the development of a generic policy framework for the preparation of Integrated Coastal Zone Management (ICZM) legislation throughout the region.	Regional	Ministries of Planning and Environment
(vii) Economic Valuation of Coastal and Marine Resources (Pilot)	Includes the design and implementation of pilot studies on the economic valuation of resources in selected coastal ecosystems at risk from sea level rise.	• Dominica • St. Lucia • Trinidad & Tobago	Ministries of Finance and Planning
(viii) Formulation of Economic/Regulatory Proposals (Pilot)	Two pilot studies would be implemented to demonstrate the design and use of economic and regulatory approaches to environmental protection in response to threats from sea level rise.	• Antigua & Barbuda • St. Kitts & Nevis	Ministries of Finance and Environment

(ii) establishment of National Implementation Units (NIUs) within an existing institution in each participating country to coordinate project activities at the country level;
(iii) strengthening of national and regional institutions directly involved in implementing various components of the project;
(iv) upgrading the skills of professionals and technicians from participating countries through short courses, workshops, and hands-on training; and
(v) technology transfer among the participating countries for adaptation planning.

PROJECT ORGANIZATION (see chart 1)

The General Secretariat of the Organization of American States (GS/OAS) would be the Grant Recipient/Executing Agency for the project. The GS/OAS would execute the project under the supervision of The World Bank as GEF Implementing Agency, and under the guidance of a Project Advisory Committee (PAC). The GS/OAS would be responsible for overall project management and technical supervision. A Regional Project Implementation Unit (RPIU) would be established in the Centre for Environment and Development of the University of the West Indies (UWICED) in Barbados to ensure effective coordination and management of project activities at the regional level.

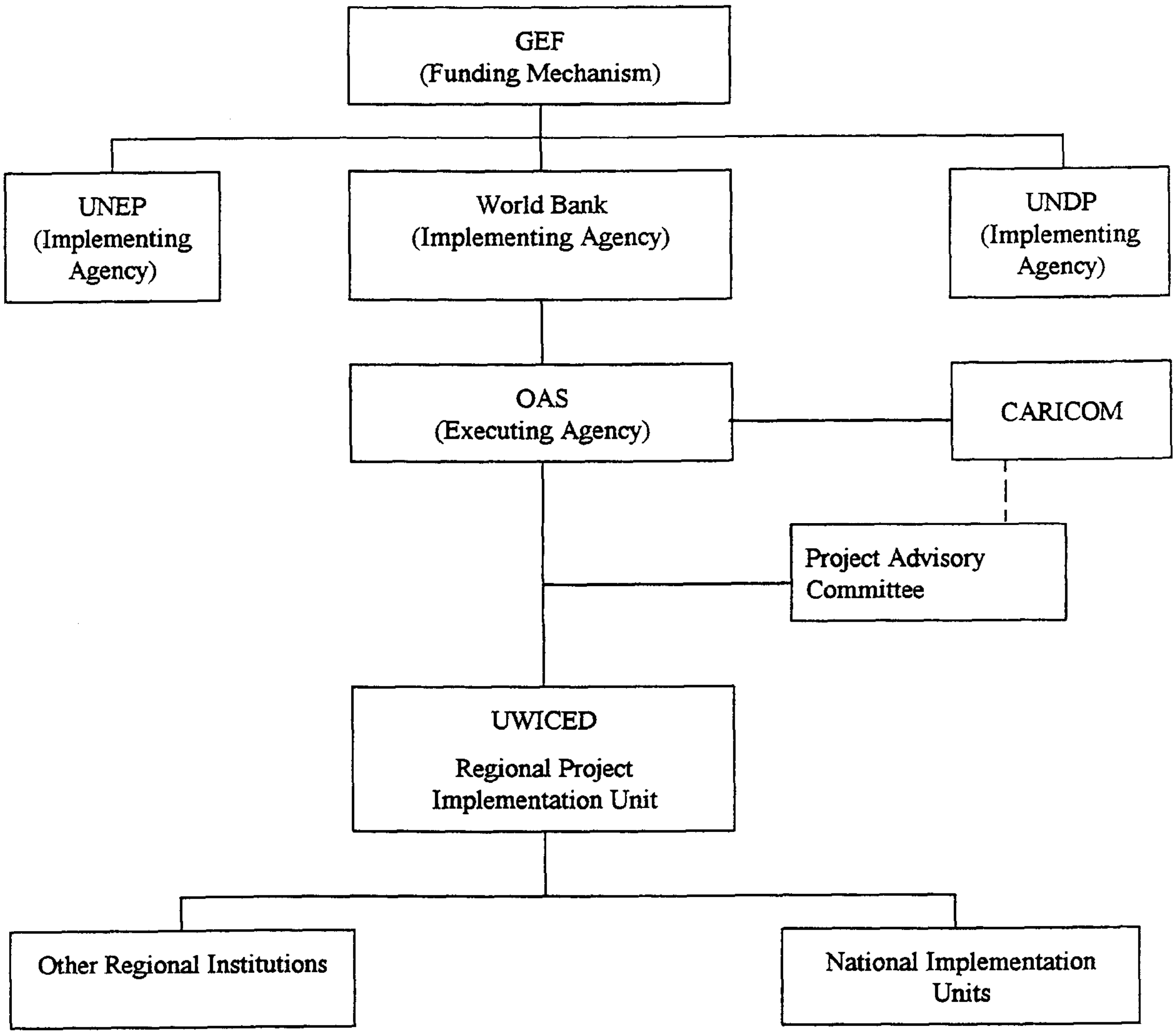
As a prerequisite for participation in the project, each country would be required to establish a National Implementation Unit (NIU) within an institution designated by the government in accordance with selection criteria to be developed by the PAC. The NIUs, working in close collaboration with the RPIU, would facilitate and coordinate project implementation at the national level.

IMMEDIATE NEXT STEPS

The CPACC Project was appraised by the World Bank in a meeting which took place in Barbados, May 29-31, 1996. Representatives of CARICOM and the UWICED participated in the meeting. The appraisal was positive, and the OAS was asked to collaborate with the World Bank on the preparation of the final project documentation. OAS also started the process of negotiations with the UWICED regarding establishment of the RPIU.

The Second Session of the Conference of Parties (COP2) to the Framework Convention on Climate Change (FCCC), which took place in Geneva from July 8 to 19, 1996, introduced new

Chart 1 Project Organization



guidelines for the National Communications obligations under the FCCC. The national communications component of the CPACC, having been formulated prior to COP2 guidelines, Ambassador Ashe therefore invited the GEF Focal Points of the participating countries to consider revising the CPACC to accommodate the new guidelines, or to treat the national communications as a stand-alone project for which additional funding would be sought. By mid September, most countries had indicated that they were pursuing the last option.

The CARICOM Secretariat in the mean time has suggested that the countries request further clarification on the COP2 guidelines from the FCCC Secretariat, and has suggested that this might best be done in the form of a regional workshop.

After consultations with Ambassador Ashe, the CARICOM Secretariat and the World Bank, the OAS informed the CPACC participating countries on October 1, 1996 that the national communications component would be removed from the project, so as not to delay the implementation of the CPACC. The CPACC still contains the same eight components as were in the original proposal. The total amount of funding is now approximately US$6.3 million, to reflect the removal of national communications.

The positions for the RPIU (project coordinator, human resources specialist, coastal zone manager, information systems specialist, and regional tidal gauge network coordinator) were advertised in regional and extra regional media. A selection committee with representatives of CARICOM, UWICED and the OAS completed the pre-selection by October 15. The project coordinator will be selected by November 15, and will be involved in the selection of the remaining staff.

Project start-up is expected during the first 2 months of 1997.

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