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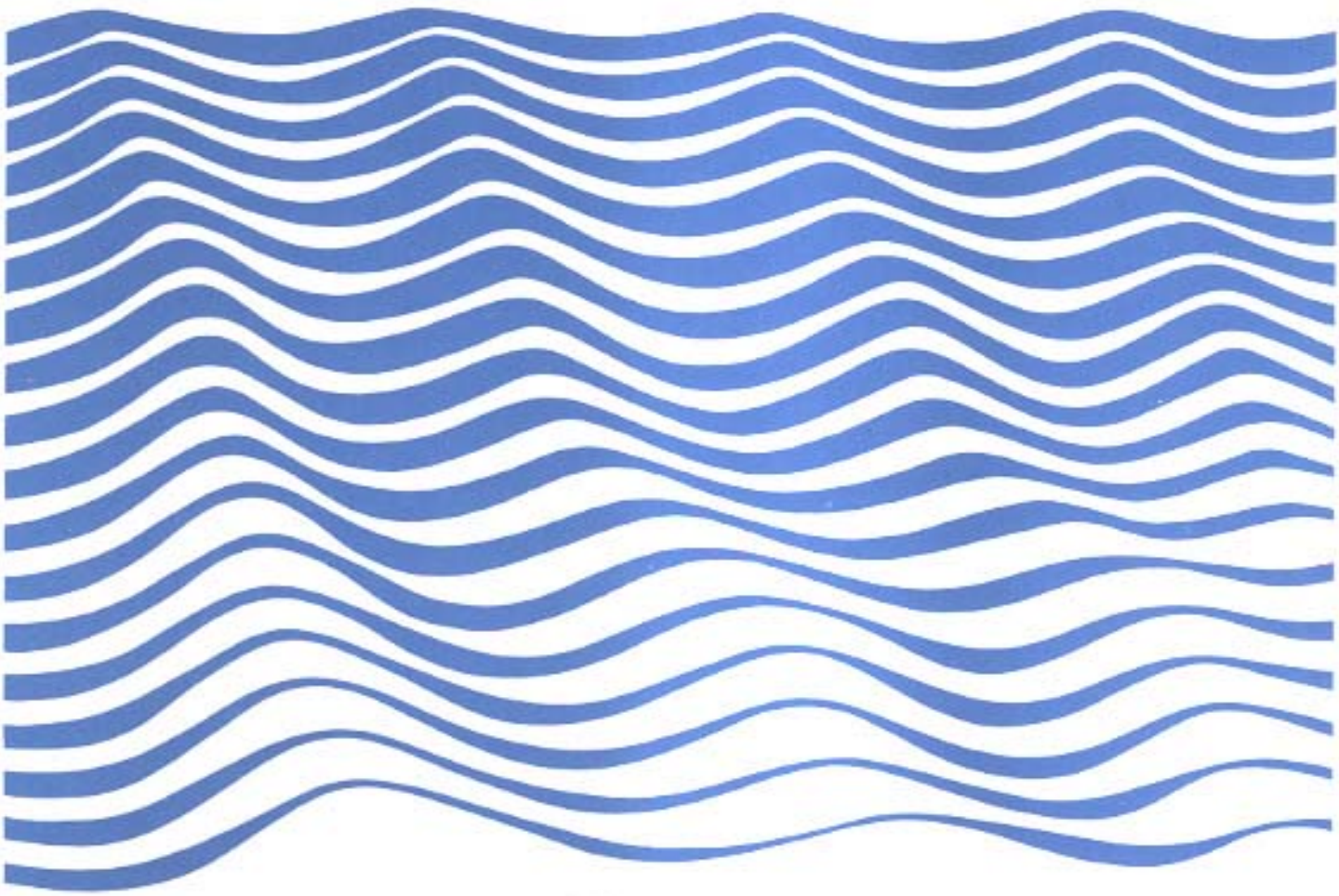
Prepared for the
UNESCO COMAR/COSALC-I Project



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PREFACE

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ABSTRACT

Presented and discussed in this document are the results of a beach monitoring programme in Dominica (1987-1992). Twenty-three beach sites were measured at three-monthly intervals. In 1989, during the monitoring period, two major hurricanes passed close to Dominica. Significant erosion followed by accretion were reported after the hurricanes; however, two years later, the beaches had not recovered their pre-hurricane levels. Very high average erosion rates were calculated (close to 1 m per year) and were related to beach sand mining. This programme was carried out within a regional UNESCO/COMAR/COSALC-1 project "Beach and Coastal Stability in the Lesser Antilles".

RESUME

Le présent document expose et examine les résultats d'un programme de surveillance continue des plages à la Dominique (1987-1992). Vingt-trois sites ont fait l'objet de mesures trimestrielles. En 1989, au cours d'une période de surveillance, deux ouragans d'une grande violence sont passés près de la Dominique. Ils ont entraîné une importante érosion suivie d'un phénomène d'accrétion ; toutefois, deux ans plus tard, les plages n'avaient pas retrouvé le niveau qu'elles avaient avant le passage des ouragans. Les calculs effectués ont fait apparaître des taux d'érosion moyens très élevés (près d'un mètre par an) qui ont été mis en relation avec l'exploitation du sable des plages. Ce programme a été exécuté dans le cadre d'un projet régional UNESCO/COMAR/COSALC-1 "Stabilité des côtes et des plages dans les Petites Antilles".

RESUMEN

En este documento se presentan y discuten los resultados de un programa de vigilancia de las playas en Dominica (1987-1992). Se efectuaron mediciones en 23 playas cada 3 meses. En 1989, durante el periodo de vigilancia, dos grandes huracanes pasaron cerca de Dominica. Se observó, después de los huracanes, una erosión importante, seguida de acumulación; sin embargo, al cabo de dos años las playas todavía no habían vuelto a su nivel de antes del paso de los huracanes. Se calcularon índices medios de erosión sumamente elevados (casi 1 m por año), poniéndose éstos en relación con la socavación de la arena de las playas. Este programa se llevó a cabo en el marco de un proyecto regional UNESCO/COMAR/COSALC-1, "Estabilidad de las playas y costas en las Pequeñas Antillas".

РЕФЕРАТ

В настоящем документе рассматриваются результаты осуществления программы берегового мониторинга (1987–1992 гг.) в Доминике. Измерения проводились в двадцати трех местах на побережье с интервалом в три месяца. В 1989 г., в период проведения мониторинга, вблизи Доминики прошли два урагана. Уровень эрозии и промоин после этих ураганов был столь значителен, что даже по прошествии двух лет побережья еще не оправились от нанесенного ущерба. Весьма высокий средний уровень эрозии составляет, согласно расчетам, около 1 метра в год и объясняется размывом песчаного побережья. Эта программа осуществлялась в рамках регионального ЮНЕСКО/КОМАР/КОСАЛК–1 проекта "Стабилизация побережья и береговой зоны Малых Антильских островов".

مستخلص

في هذه الوثيقة تعرض وتناقش نتائج برنامج مراقبة الساحل في دومينيكا (١٩٨٧-١٩٩٢). ولقد تم قياس ثلاثة وعشرين موقعا ساحليا على مراحل، بمعدل كل ثلاثة أشهر. وخلال الفترة التي شملتها عملية الرصد في عام ١٩٨٩، سجل مرور اعصارين كبيرين بالقرب من دومينيكا. ولوحظ أنه حدث تحات شديد في التربة تلاه تراكم لها عقب مرور الاعصارين؛ ولكن بعد مضي عامين، كانت السواحل لا تزال دون المستوى الذي كانت عليه قبل مرور الاعصارين وسجل متوسط مرتفع لمعدلات التحات (بمقدار متر واحد تقريبا كل سنة)، وعزي ذلك الى تجريف تربة الشاطئ لأغراض التعدين. ونفذ هذا البرنامج في اطار المشروع الاقليمي اليونسكو/كومار/كوسالك -١ المسمى "استقرار الشواطئ والسواحل في جزر الأنتيل الصغرى".

摘　　要

本文件所介绍和讨论的内容系多米尼加海滩监测计划（1987--1992年）的监测结果。每隔三个月对二十三处海滩进行了测量。1989年，在监测期间，有两次巨大的飓风从多米尼加附近经过。飓风过后，出现了严重的侵蚀和海滩堆积；两年之后，海滩仍未恢复到飓风之前的水平。根据计算，侵蚀的平均速度是很快的（每年近1 米），而且与海滩砂的开采有关。这次计划是在教科文组织／沿海系统地区间项目／拉丁美洲及加勒比地区海岸系统研究与培训的一项地区项目“小安的列斯群岛海滩和沿岸的稳定”的范围内进行的。

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1. EXECUTIVE SUMMARY

Beaches are important to Dominica and other Eastern Caribbean Islands for several reasons: these include local recreation, tourism, sources of fine aggregate for construction, protection for coastal lands and infrastructure, and fish landing sites. Dominica, together with other islands in the region, has been experiencing coastal erosion for several years, possibly several decades. The causes of the erosion include high wave energy during winter swell events, tropical storms and hurricanes, probable sea level rise, extraction of sand from the coastal zone for construction, building too close to the active beach zone, and pollution which impacts on nearshore marine systems (seagrass beds and coral reefs) which in turn impact on beach and coastal dynamics.

This report describes and analyses the results of a beach monitoring programme that was started in Dominica in 1987, within a regional UNESCO COMAR Project (Major Interregional Project on Research and Training Leading to the Integrated Management of Coastal Systems). A sub project of COMAR, COSALC-I, deals with "Beach and Coastal Stability in the Lesser Antilles". Previous components of this project in Dominica consisted of an evaluation and workshop to determine priorities in the coastal zone, and the preparation of audio visual aids relating to beach and coastal stability. The monitoring was carried out by the Forestry and Wildlife Division of the Ministry of Agriculture, and technical assistance was provided by a UNESCO Consultant.

Some 23 beach sites were measured at three-monthly intervals over the period 1987-1992. There were, however, some significant gaps in the data record. The period of measurement includes two major hurricanes: Hurricane Gabrielle and Hurricane Hugo in September 1989. These two hurricanes passed relatively close to Dominica. The report presents and analyses the data and trends for each site. Seasonal changes were also determined.

As regards the hurricanes, the west coast suffered the most severe damage from Hurricane Hugo. There was a mean decrease in beach area of -17% immediately after this hurricane. In the following two years, most of the beaches showed partial recovery, although it is significant to note that most of these did not recover to their pre-hurricane levels; thus, the hurricane had a lasting effect. Of those beaches measured, the northeast coast, from Londonderry to Castle Bruce, showed the most severe erosion after Hurricane Gabrielle, and again the beaches did not recover to their pre-hurricane levels.

Beach area and beach width measurements were analysed to show the overall change. On average, the sites showed an erosion rate of -1m (-3ft) per year, which is a high rate of change. This was broken down on a coastal basis as follows:

West coast - mean erosion rate	=	-0.7m per year (2ft/yr)
North coast - mean erosion rate	=	-0.3m per year (1ft/yr)
East coast - mean erosion rate	=	-1.9m per year (6ft/yr).

The sites showing the most serious erosion were: Pagua Bay, Londonderry, Rockaway #2, Bout Sable South and Scotts Head. It was significant to note that while there was no clear relationship between beach mining and the amount of erosion, most of the sites experiencing the highest erosion rates are among those used for mining. At Bout Sable, where one site is mined and the other is not, the beach area and width measurements indicate that the mined site has experienced more than twice the erosion of the unmined site.

The data indicate beach erosion throughout Dominica, and against a global climatic change background of sea level rise and increased hurricane frequency, it is essential to continue the monitoring to provide the information for future decision making for the development, utilization and preservation of the coastline of Dominica.

2. FOREWORD

Dominica has an area of 751 sq km and is the most northerly of the Windward Islands in the Eastern Caribbean. It is located at latitude 15°20' N and longitude 61°22'W. The population in the 1981 census was 74,000 people. The economy is predominantly agricultural with a growing tourism sector.

Dominica is a mountainous and volcanic island with very rugged, steep terrain and a narrow coastal plain, where most of the population live. The coastal shelf is narrow, less than 1 km wide, particularly on the west coast. The beaches are generally narrow and consist of stones and black volcanic sand. They exist mainly in embayments, separated by lengths of steep cliffs. Coral reefs are limited mainly to the southwest and north coasts. On the north coast, between Hampstead and Woodford Hill, the beaches consist of a mixture of black sand and coral sand.

The beaches in Dominica are important for a number of reasons:

1. They act as a buffer zone and protect the land behind from wave action. This is particularly important along the west coast where there is extensive infrastructure (roads, houses, industrial development) behind the beach.

2. They provide a recreational resource for local residents and visitors.

3. Although Dominica's tourism is focussed on nature tourism (ecotourism) rather than the traditional sun-sea-sand tourism of other Caribbean Islands, beaches still form an important part of the tourism product.

4. Beaches provide a source of fine aggregate for construction.

5. They provide fish landing sites and areas for beaching boats.

6. They provide a habitat for animals and nesting sites for sea turtles.

7. They are an aesthetically pleasing part of the environment.

There are no long term data, covering past decades, relating to coastal changes in Dominica. Visual evidence indicates erosion. The centre of Hurricane David, a category 4 hurricane, passed over Dominica in 1979. The damage to the infrastructure and the beaches was catastrophic; evidence of such erosion can still be seen at sites such as Massacre where the road ends in the sea. There are several locations where the coastal highway is being undermined by wave action and has had to be protected by extensive gabion systems.

The causes of the erosion are complex. As yet, data do not exist to quantify or prioritize the causes. However, the causes can be listed as follows:

1. *Natural causes*: These include high wave energy during tropical storms, hurricanes and winter swells.
   a) Tropical storms and hurricanes cause high wave energy which may be accompanied by storm surges of +2 m.
   b) High wave energy is experienced in the winter months, November to April, in the form of high swell waves. These are formed by intense low pressure systems in the Atlantic Ocean. Such waves travel south as swell to affect the Eastern Caribbean Islands, including Dominica. They cause considerable erosion on north, west and east coasts, but their effects are especially severe on the western coasts which usually only experience low wave energy.

2. *Man-made causes*: These include beach sand mining, pollution and building too close to the active beach area.
   a) Sand is extracted from beaches in Dominica and other Caribbean Islands for construction purposes. This is controlled by legislation, but implementation is a major problem.
   b) Land-based pollution impacts offshore communities, particularly seagrass beds and coral reefs; these systems play an important role in beach stability.
   c) As beaches erode, the position of the beach moves inland, thus it is important to leave a buffer zone between the beach and permanent development such as roads, houses. With the shortage of flat land in Dominica, development has often extended almost to the water line, thus making it necessary to build expensive sea defence works.

3. *Other causes*: These relate to sea-level changes. Unfortunately, there are no tide gauge data relating to sea-level changes in Dominica. A rising sea-level will increase erosion. While global sea-level change data exist, specific information relating to Dominica, which would include possible tectonic rise, are unavailable at present.

Against this overall background of sparse data, the beach monitoring programme was established in Dominica, to try and provide quantitative data on beach changes. Eventually it is hoped that measurements of waves, currents and sea-level changes can be included in the programme.

3. METHODOLOGY

The beaches are surveyed from a marked reference point at the back of the beach, this may be a paint mark on a tree or a wall etc. The reference point acts as the starting point for the profile. The beach profile is surveyed using an Abney level and tape measure and ranging poles. The poles are set up at breaks of slope and the profile is measured along a fixed orientation. The end point of the profile is usually the offshore step, i.e. when and/or where conditions permit. Beach profiles are measured at three-monthly intervals.

The profiles are analysed using a Lotus macro developed by Dr. D. Gray of St. Mary's University, Halifax, Canada. This uses the spreadsheet programme to calculate the area under the profile using a fixed vertical drop which was determined at the first measurement for each site. The length of the profile is also calculated, this represents the beach width at the time of measurement.

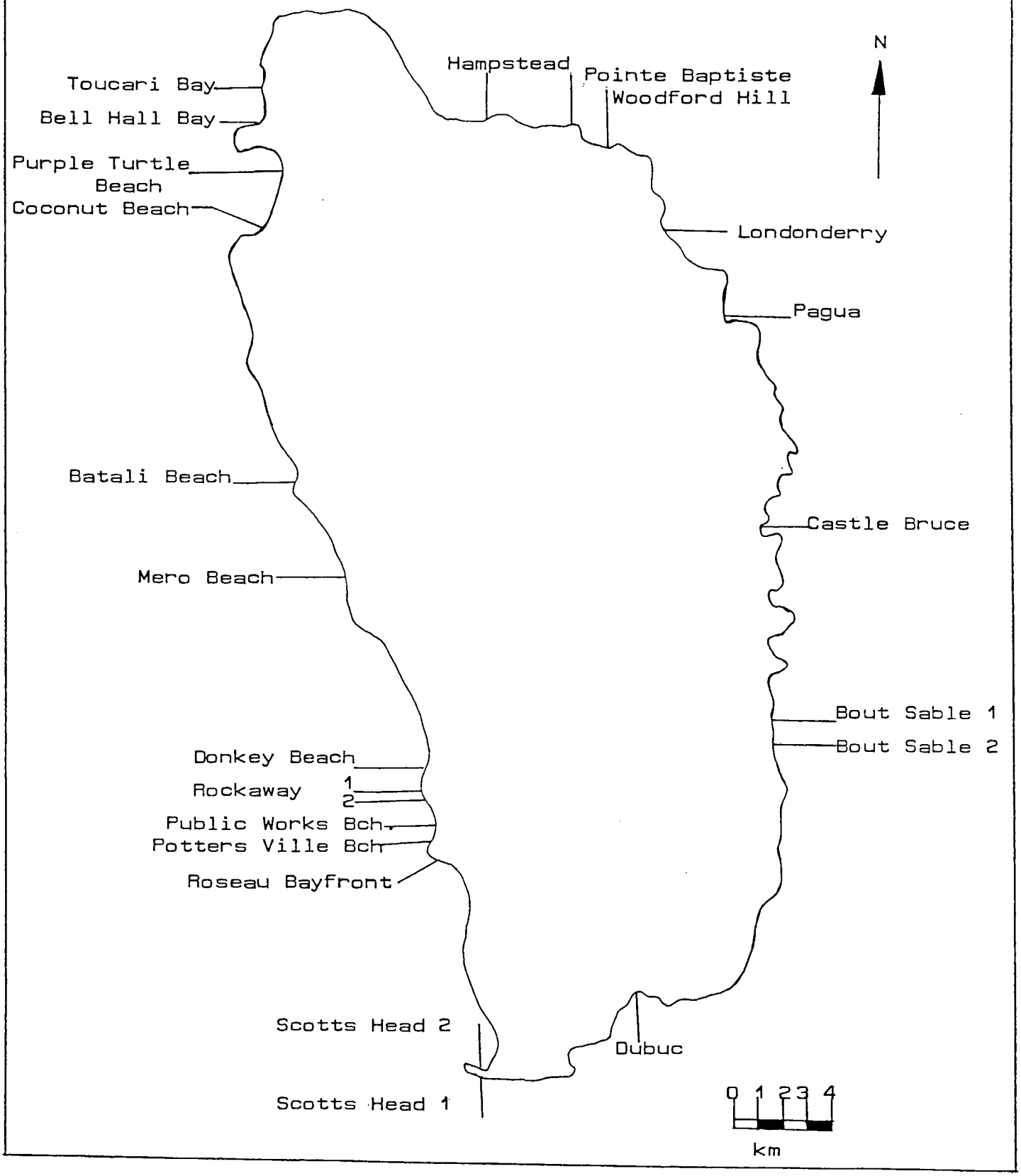
Twenty three sites on twenty one beaches are measured in Dominica – these are shown in Figure 1. The goal was to measure the beaches at three-monthly intervals and this was achieved between 1987 and 1989. Additional measurements were made after Hurricanes Gabrielle and Hugo in September 1989 at monthly intervals at some sites. However, in the years 1990 to 1992, it was not possible to measure the beaches at three-monthly intervals due to a shortage of manpower and indeed there was a twelve-month gap in the data record between August 1990 and August 1991. The last measurements for most sites was in February/March 1992. In order to try and smooth out some of the irregularities in the data frequency, average values have been calculated for each year. However, an annual average based on several data points such as 1988 is more representative than an average based on only two data points such as 1991, or one data point as in 1992, and this must be borne in mind when comparing the figures.

Each site has been described separately in this report in Appendix I. A data table has been prepared for each site, this shows the profile area and the profile width for each measurement. This is followed by a summary table where mean values have been calculated for each year for profile area and profile width. In addition the percentage change in profile area from year to year has been calculated. The year 1989 was subdivided into "before the Hurricanes" (Gabrielle and Hugo) and "after the Hurricanes".

Profile area is the more accurate measurement since it incorporates profile width and slope. However, profile width has been included on its own. This is for two main reasons. Firstly, from an administrator's viewpoint, it is easier to visualise and explain that a beach has narrowed by say 5 metres than it is to understand that the profile area has decreased by 10%. Secondly, long-term beach change data are usually quoted as erosion rates, e.g. metres eroded per year over a 20-year period; these can be compared directly with the beach width changes.

Within the individual site analysis, the data has been used to determine seasonal changes at that site as well as longer term trends. Bar graphs are presented to

FIGURE 1 LOCATION OF BEACH PROFILE SITES



illustrate the data. In addition the profile width data have been used to determine erosion rates.

4. RESULTS AND DISCUSSION

As previously stated the results for each site are included in Appendix I. This section will discuss the general seasonal trends, the impacts of the two hurricanes in 1989, and the overall trends.

4.1 Seasonal Trends

For all the sites bar graphs have been prepared showing the seasonal changes in 1988; see Appendix I. (In some cases the data for the two measurements of 1987 were also graphed). This year was chosen because measurements were collected regularly at three-monthly intervals at all sites. In addition the data for the years after 1989 were, at many sites, influenced by post hurricane recovery, and this tended to distort the seasonal trend.

At the west coast sites, from Scotts Head to Toucarie Bay, the pattern of lower values during the months November to March as compared with the period May to August, was apparent. One of the best examples was at Coconut Beach; see Figure 2. During most of the year low wave energy is experienced on the west coast, however, during the winter months high swells emanating from intense North Atlantic storms cause beach erosion. There were some exceptions to this general trend, namely at Rockaway #1, Donkey Beach and Belle Hall. The reason for this is not known. However, it must be noted that, bearing in mind the irregularity of the winter swell events, the beaches would have to be measured at least once a month to determine seasonal trends accurately.

Along the north coast, Hampstead and Woodford Hill showed a similar trend of erosion during the winter months, but the pattern was not so clear at Pointe Calibishie.

Along the east coast, there was no clear pattern. Some sites showed erosion during the months of March and May. This correlates with the usual pattern of the Trade Winds, when there are higher wind speeds and therefore higher wave energy during the months December through April. This pattern is most clearly seen on Figure 3, where the beach area values over the entire six years have been plotted for Pagua Bay. Other sites that showed this same trend in 1988 are Castle Bruce, Bout Sable South and to some extent, Londonderry. However, as on the west coast, beaches would have to be measured at least monthly to determine seasonal trends accurately.

4.2. Effects of the Hurricanes

During the period of analysis there were two major hurricanes which passed close to Dominica, these were Hurricane Gabrielle and Hurricane Hugo. Hurricane Gabrielle passed 400 miles (640 km) northeast of Dominica between 3rd and 5th September, 1989. This was a large and well developed hurricane which generated swells which affected the windward coasts of Dominica and many other Caribbean

FIGURE 2

Coconut Beach
Seasonal Changes 1988

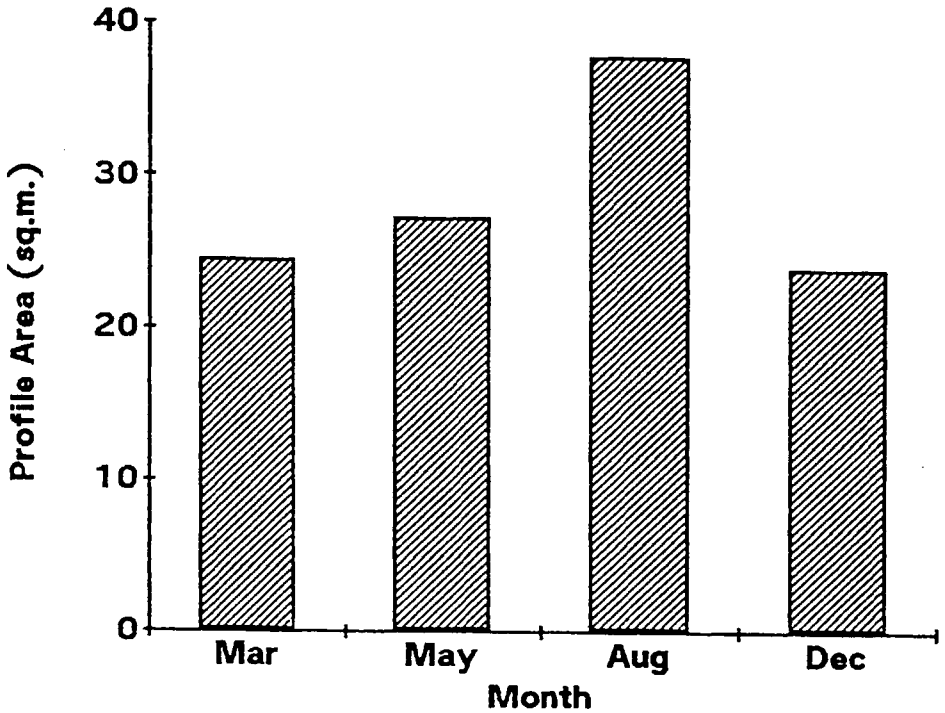
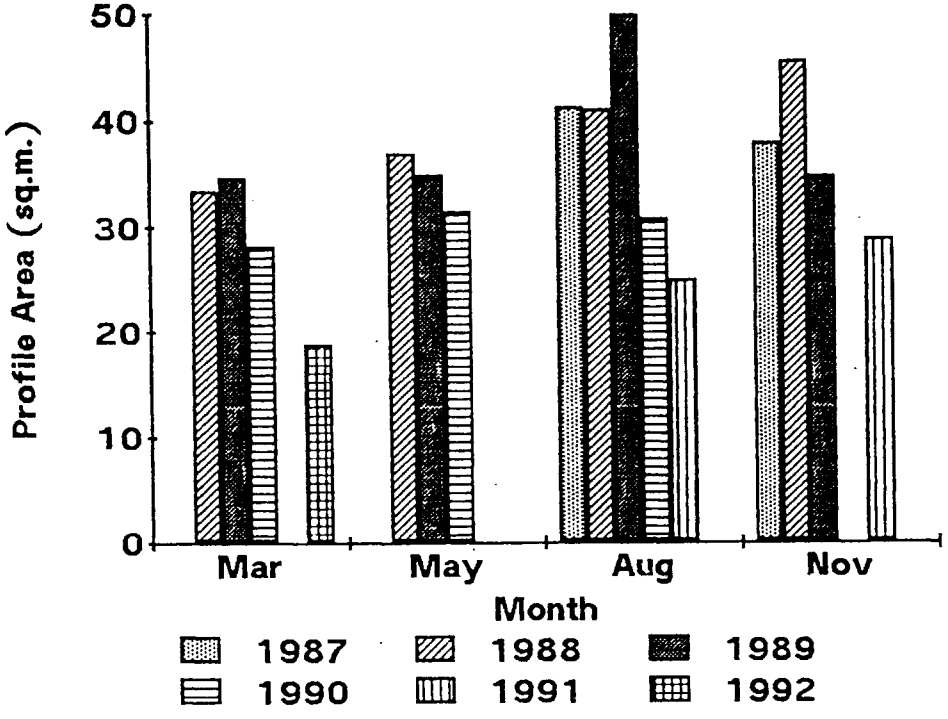


FIGURE 3

Seasonal Changes
Pagua Bay 1987-1992



Islands. Figure 4 shows the track of Hurricane Gabrielle, since this hurricane passed to the north and east of Dominica, the most severe swells were experienced on the north and east coasts. Hurricane Gabrielle did not make a landfall in the Caribbean.

Hurricane Hugo passed through the Leeward Islands, and passed 50 miles (80 km) to the north of Dominica between 16th and 17th September 1989, Figure 4 shows the track of Hurricane Hugo. Hurricane Hugo was a Category 4 hurricane with sustained winds of 140 mph (224 km/hr). The southwestern sector of the hurricane was the most intense and it was the western coast of Dominica which received the most severe damage from Hurricane Hugo. The north and east coasts had already been seriously eroded by Hurricane Gabrielle and little further damage resulted there.

Table 1 lists for each site the hurricane which had the most serious effect, the effect the hurricane had on the beach, the % change in beach area (this compared the pre-hurricane measurement with the post-hurricane measurement), and a qualitative description of the beach recovery after the hurricane up to the last measurement in 1992. (The detailed quantitative data for each site may be obtained from Tables 4-26).

Along the west coast, Hurricane Gabrielle caused only slight erosion. It was Hurricane Hugo that caused the most severe changes. Of the fourteen west coast sites, there was an average loss of beach area of -17%. Eleven beach sites showed severe erosion and of these ten showed only partial recovery in the two years after the hurricane. Thus at these ten sites, while there was some accretion and recovery after the hurricane, the beaches never recovered to their pre- hurricane levels. In this respect the hurricane had a lasting effect on the beaches. Only at one site, Pottersville, did the beach recover to its pre-hurricane level. It is noticeable that the most severe erosion was along the northern part of the west coast from Prince Rupert Bay to Toucarie Bay. There were three sites on the west coast which experienced accretion after Hurricane Hugo, these were Roseau Bayfront, Rockaway #1 and Batalie Beach. At Roseau Bayfront large boulders were thrown up onto the beach, however, the reason for the accretion at the other two sites is unknown.

The three sites on the north coast did not show a clear pattern. At Hampstead and Pointe Baptiste there was erosion caused by Hurricane Gabrielle, however, both these sites recovered to their pre-hurricane levels in the following two years. At Woodford Hill there was significant accretion after Hurricane Gabrielle. The average change in profile area for these three sites was zero, the erosion at two of the sites was balanced by accretion at the third site, so overall there was no net change for the north coast beaches. Hurricane Hugo had little further effect at these sites.

Along the east and southeast coasts, the three northern sites, Londonderry, Pagua and Castle Bruce, showed severe erosion due to Hurricane Gabrielle. The average loss in beach area was -28%, and the beaches did not recover to their pre-hurricane level in the following two years. The south and southeast coast sites, Bout Sable and Dubuc, showed very little change after the hurricanes.

Thus in summary, the west coast suffered the most severe erosion from Hurricane Hugo, this loss was permanent in view of the fact that most of the beaches have not returned to their pre-hurricane levels in the following two years. The

FIGURE 4 TRACKS OF HURRICANES GABRIELLE AND HUGO OVER THE EASTERN CARIBBEAN IN SEPTEMBER 1989

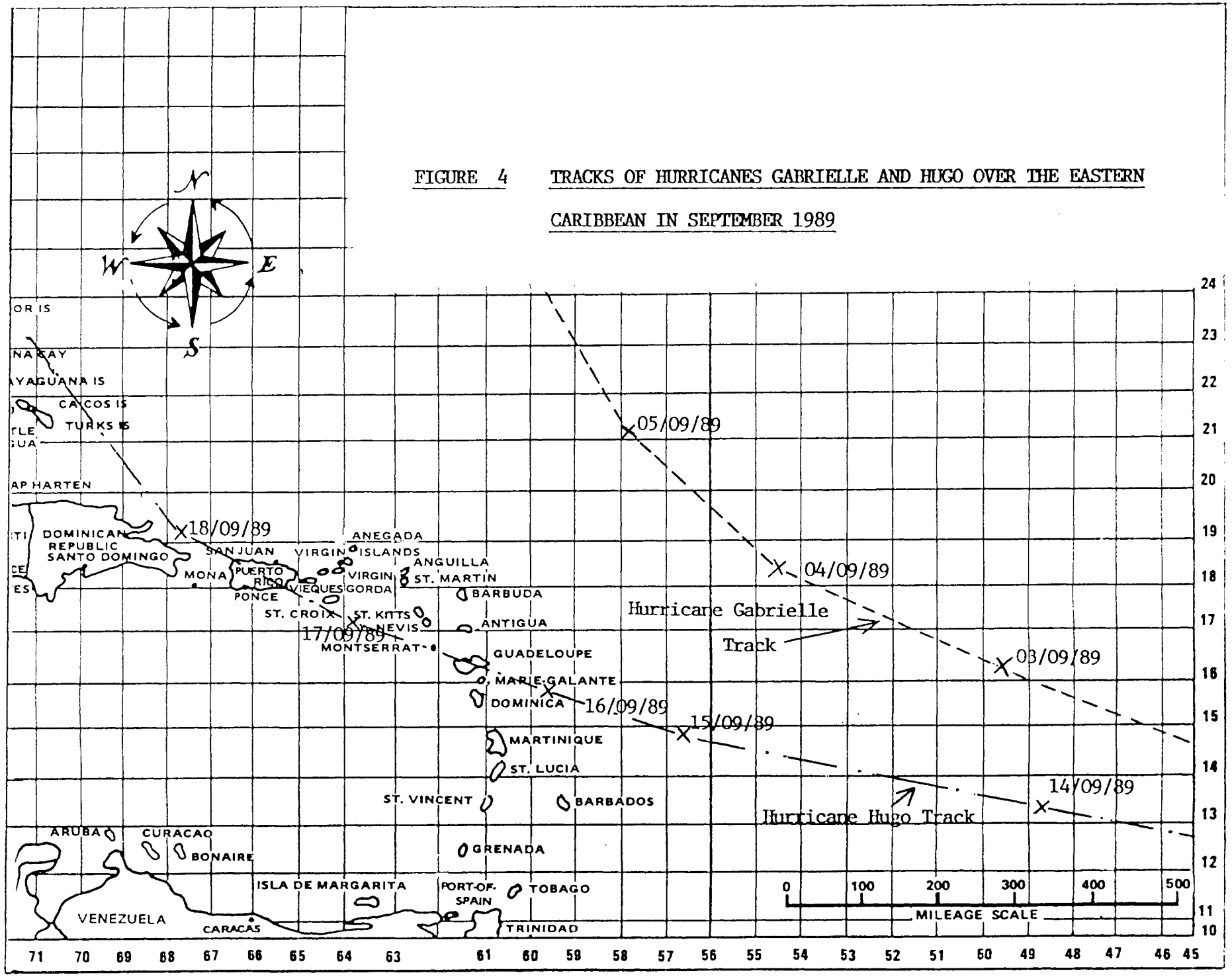


TABLE 1 EFFECTS OF HURRICANES GABRIELLE AND HUGO ON THE BEACHES OF DOMINICA

Site	Hurricane Name	Nature of Change	% Loss of Beach Area	Recovery Oct.'89-Feb.'92
Scotts Head Atl.	Hugo	Erosion	-11%	None
Scotts Head Car	Hugo	Erosion	-16%	None
Roseau Bayfront	Hugo	Accretion	+23%	
Pottersville	Hugo	Erosion	-17%	Total
Woodbridge	Hugo	Erosion	-21%	Total
Rockaway #1	Hugo	Accretion	+ 6%	
Rockaway #2	Hugo	Erosion	-35%	Partial
Donkey Beach	Hugo	Erosion	-15%	Partial
Mero	Hugo	Erosion	-27%	Partial
Batalie Beach	Hugo	Accretion	+24%	
Coconut Beach	Hugo	Erosion	-51%	Partial
Purple Turtle	Hugo	Erosion	-33%	Partial
Belle Hall	Hugo	Erosion	-27%	Partial
Toucarie Bay	Hugo	Erosion	-37%	Partial
Hampstead	Gab	Erosion	- 5%	Total
Pointe Baptiste	Gab	Erosion	-13%	Total
Woodford Hill	Gab	Accretion	+19%	
Londonderry	Gab	Erosion	-28%	Partial
Pagua Bay	Gab	Erosion	-49%	Partial
Castle Bruce	Gab	Erosion	- 6%	Partial
Bout Sable N.	Gab	Erosion	- 3%	Total
Bout Sable S	Gab	Erosion	- 6%	Total
Dubuc Bay	Gab	Accretion	+ 5%	

Gab = Gabrielle
Recovery :
None - beach continued to erode after the hurricane
Partial - beach recovered somewhat after the hurricane but not to pre-hurricane levels
Total - beach recovered to pre-hurricane levels after the hurricane.

northeast coast, from Londonderry to Castle Bruce, showed severe erosion after Hurricane Gabrielle, again those beaches did not return to their pre-hurricane levels in the following two years. These findings are comparable to those for Nevis where the west coast experienced very severe erosion after Hurricane Hugo, while the north coast of that island experienced little change, Cambers (1992).

4.3 Overall Trends 1987 - 1992

Figures 5 - 10 show the trends in beach change at each site on the west coast. The average annual profile area was plotted over time. Figure 5 shows the southern section of the west coast. It is very obvious that the two profiles at Scotts Head behave in a similar manner and show an erosion trend. Similarly Pottersville and Woodbridge behave in a similar manner, although the Woodbridge profile had to be discontinued in 1990.

Figure 6 shows the central section of the west coast and here there does not seem to be any clear pattern. In contrast, the northern part of the west coast, Figure 7, shows a very clear trend with all the profiles behaving in the same manner - there was erosion after the hurricane in 1989, then some partial recovery, but not to pre-hurricane levels.

On the north coast, see Figure 8, Hampstead and Pointe Baptiste show similar trends and are basically stable or slightly accreting. Woodford Hill, however, does not behave in the same manner and here the changes are very dramatic.

The three sites on the northern section of the east coast, Figure 9, all behave in a similar manner, with erosion being the dominant trend, especially at Pagua Bay. The three sites on the south and east coast are shown in Figure 10. The two profiles at Bout Sable do not act in unison and as was shown in Appendix 1, one site is actively mined for sand, so this may explain some of the differences. Dubuc Bay showed a similar trend to that of Bout Sable North.

Table 2 groups the data together and shows the total percentage change in profile area between 1987 and 1992. The second column shows the change in profile area as an annual average. Of the twenty-three sites, eighteen showed erosion. Those sites showing the most severe erosion were:

Pagua Bay	-52%
Scotts Head Caribbean	-47%
Scotts Head Atlantic	-40%
Rockaway #2	-36%
Bout Sable South	-34%

At Pagua Bay the beach area had decreased by more than 50% between 1987 and 1992, this is a very significant amount of erosion.

The average change in beach area for all twenty three sites over the five-year period was -14%. This represents a reduction of 3% per year. This would indicate that overall the beaches are eroding and becoming narrower. When this happens the

FIGURE 5

West Coast - Southern Section
Annual Changes

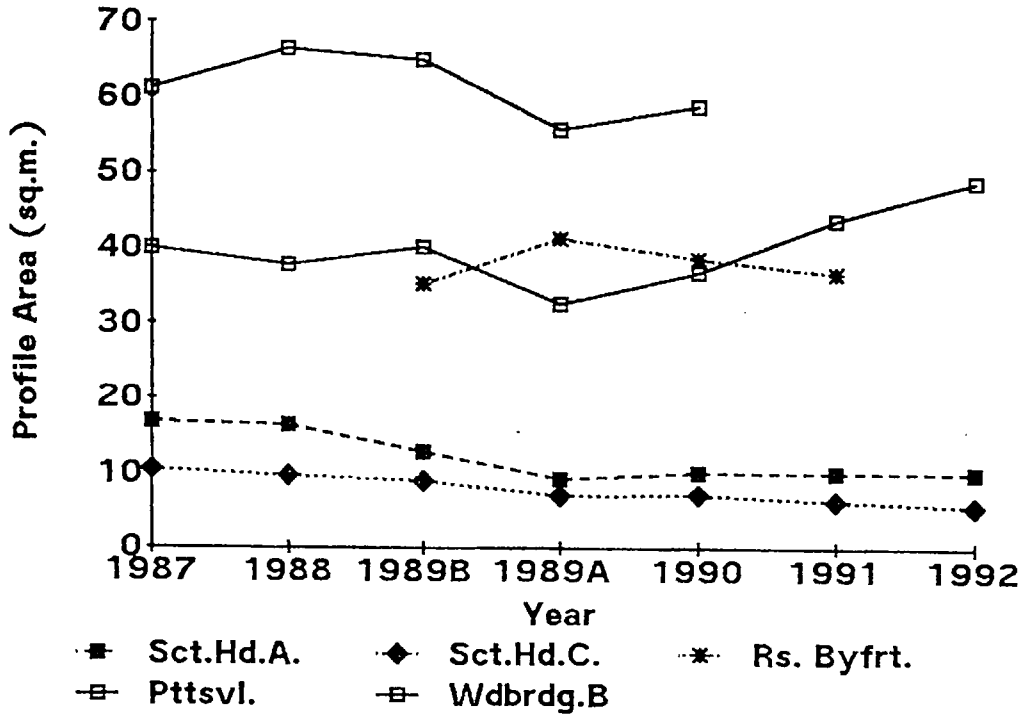


FIGURE 6

West Coast Central Section
Annual Changes

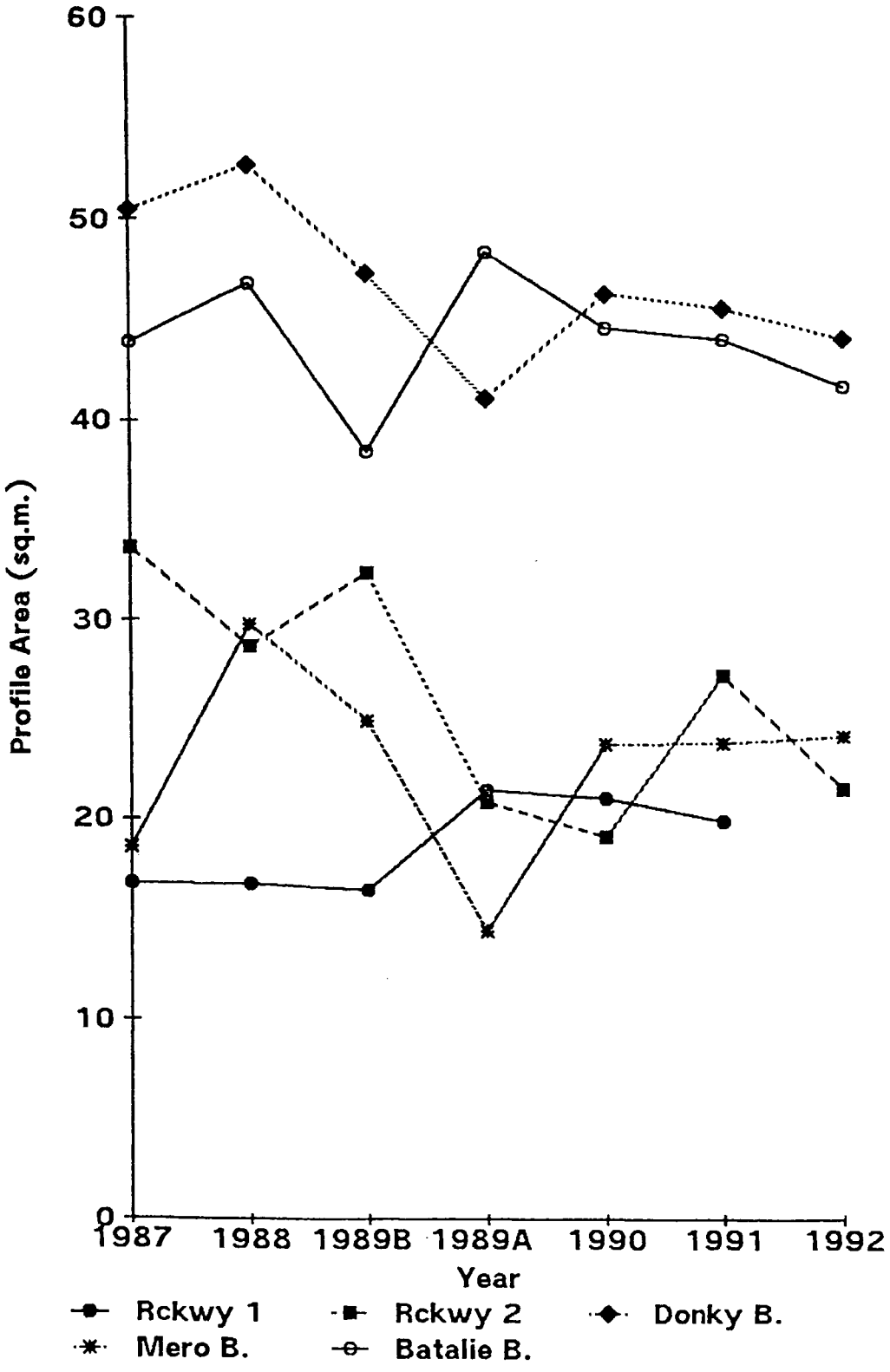


FIGURE 7

West Coast - Northern Section
Annual Changes

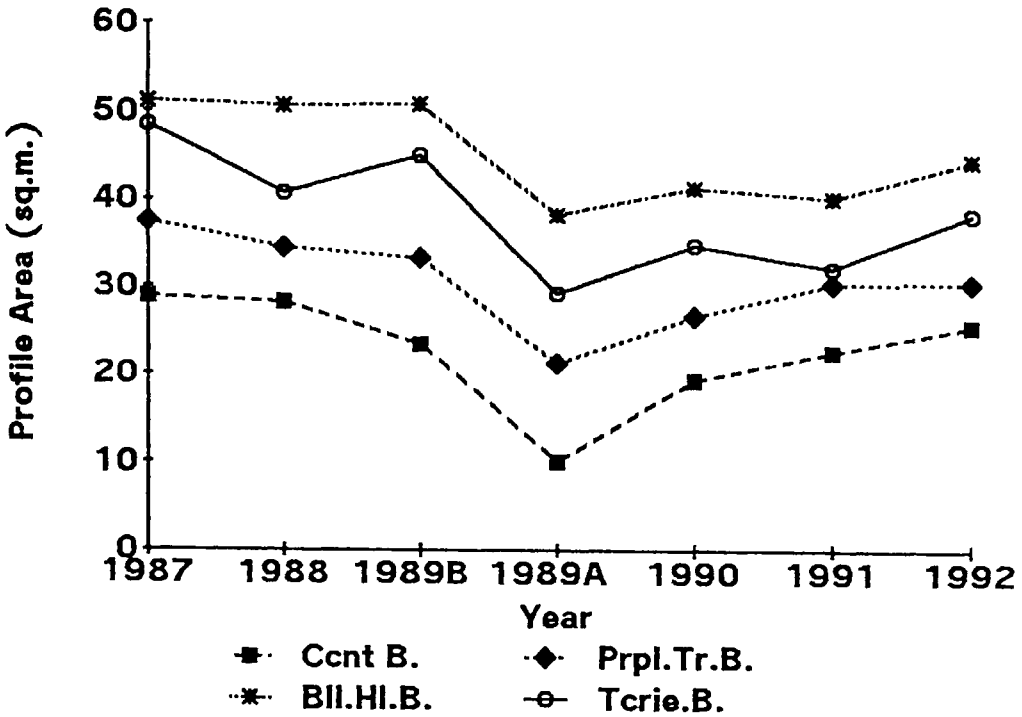


FIGURE 8

North Coast
Annual Changes

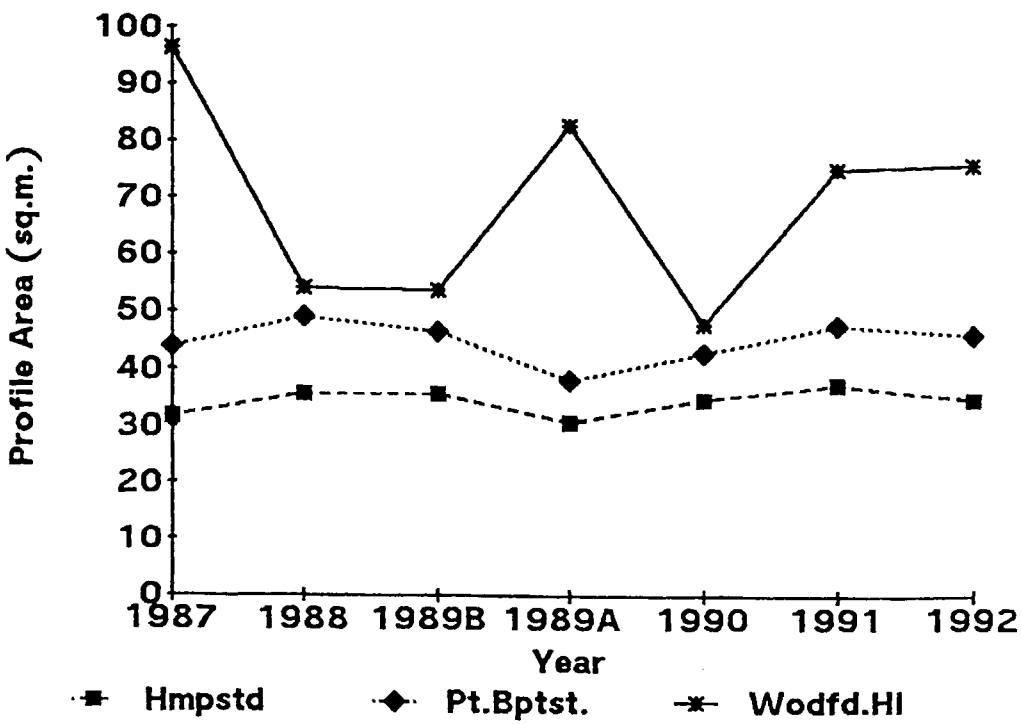


FIGURE 9

East Coast
Annual Changes

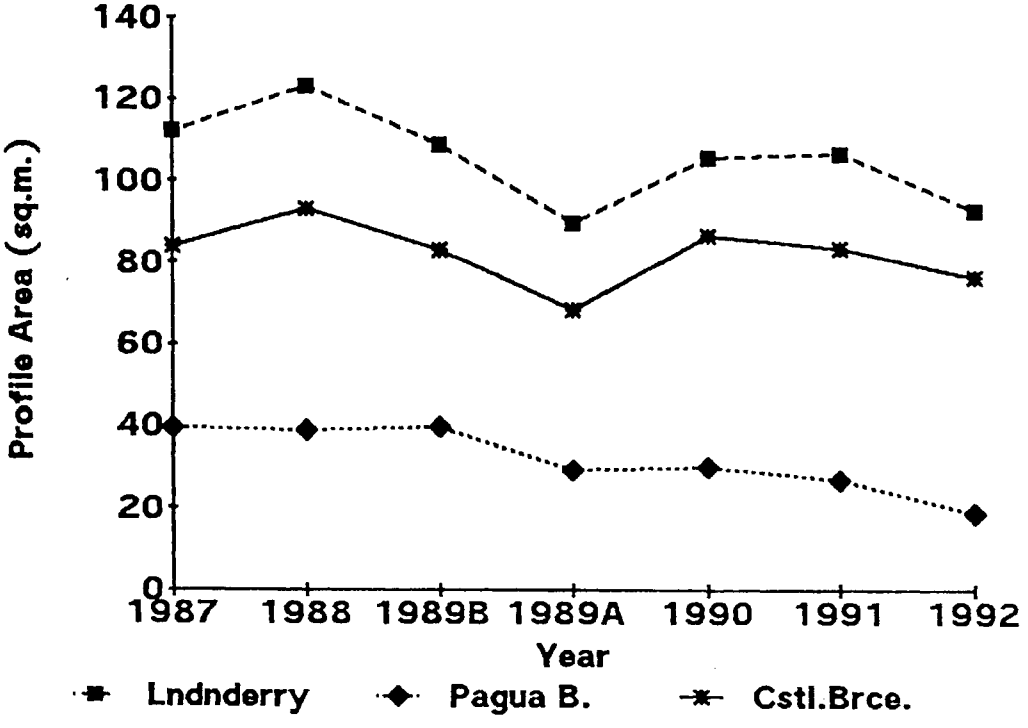


FIGURE 10

Southeast Coast
Annual Changes

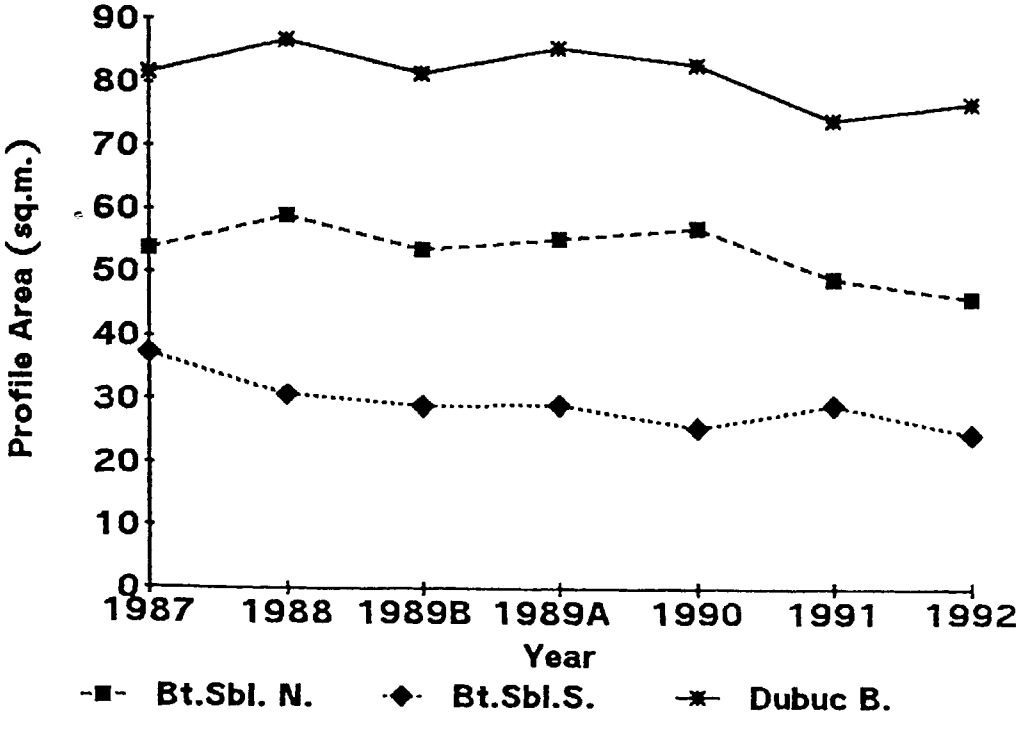


TABLE 2 CHANGES IN BEACH AREAS 1987 - 1992

Site	Change in Beach Area	
	Total Change Between 1987 and 1992 (%)	Annual Change Between 1987 and 1992 (%)
Scotts Head Atlantic	- 40	- 8
Scotts Head Caribbean	- 47	- 9
Roseau Bayfront	+ 4	+ 2
Pottersville	+ 22	+ 4
Woodbridge Bay	- 11	- 3
Rockaway #1	+ 18	+ 5
Rockaway #2	- 36	- 7
Donkey Beach	- 13	- 3
Mero Beach	- 19	- 4
Batalie Beach	- 5	- 1
Coconut Beach	- 12	- 2
Purple Turtle Beach	- 19	- 4
Belle Hall Beach	- 13	- 3
Toucarie Bay	- 21	- 4
Hampstead Beach	+ 9	+ 2
Pointe Baptiste	+ 5	+ 1
Woodford Hill	- 21	- 4
Londonderry	- 18	- 3
Pagua Bay	- 52	-10
Castle Bruce	- 9	- 2
Bout Sable North	- 14	- 3
Bout Sable South	- 34	- 7
Dubuc	- 6	- 1
Mean	-14	- 3

beach will naturally try to establish a new profile further inland, however, when there is a natural barrier such as a cliff, or a man-made barrier such as a wall, preventing this re-establishment, then the beach will continue to narrow and steepen and will eventually disappear altogether.

Table 2 showed that there were five sites which were more stable and had shown accretion over the five-year period, these were:

Pottersville	+22%
Rockaway #1	+18%
Hampstead	+ 9%
Pointe Baptiste	+ 5%
Roseau Bayfront	+ 4%

The profile at Rockaway #1 has had to be discontinued because of inaccessibility and the Roseau site only covered a two-year data period. The two north coast sites are well protected with reefs and appear to be fairly stable, they are not seriously impacted by man.

Table 3 shows the total change in beach width over the period 1987 - 1992. As earlier explained this is not such an accurate indicator of change as profile area, but it is a parameter that is often easier to understand. The second column in the table shows the change in beach width as an annual average, or an erosion/accretion rate. The third column in the table indicates whether the site is used for the mining of aggregate (sand, stones, or boulders).

This table showed that of the twenty three sites, twenty one showed erosion or a decrease in beach width. Pottersville and Rockaway #1 showed an increase in beach width. The sites at Roseau Bayfront, Hampstead and Pointe Baptiste showed slight narrowing of the beach. Table 2 showed that the area of these three sites increased. If the area measurement increased and the width decreased, this would indicate the profile steepened which is usually indicative of erosion.

The sites showing the most severe beach narrowing are similar to those showing the most severe reduction in profile area:

Pagua Bay	-25m
Londonderry	-19m
Rockaway #2	-12m
Bout Sable South	-12m

The difference between Tables 2 and 3 in the sites showing the most severe erosion is due to the fact that beach width is expressed as an absolute figure, while profile area was calculated as a percentage.

Table 3 shows that the mean total change in beach width over the period 1987-1992 was -5.2 m, this represents an erosion rate of -1m per year, which in the context of the Eastern Caribbean is a very high rate of erosion.

TABLE 3 CHANGES IN BEACH WIDTH 1987 - 1992 AND MINING ACTIVITIES

Site	Beach Width Change		Beach Mining Activity
	Total Change 1987-1992 (m)	Annual Change Rate (m/yr)	
Scotts Head Atlantic	- 4.037	- 0.8	Minor stone
Scotts Head Caribbean	- 5.489	- 1.1	None
Roseau Bayfront	- 0.446	- 0.2	Minor
Pottersville	+ 4.635	+ 0.9	Minor sand & gravel
Woodbridge Bay	- 3.501	- 1.2	Minor
Rockaway #1	+ 1.274	+ 0.3	None
Rockaway #2	-12.446	- 2.5	None
Donkey Beach	- 3.870	- 0.8	Significant
Mero Beach	- 1.181	- 0.3	None
Batalie Beach	- 1.668	- 0.3	Significant
Coconut Beach	- 3.430	- 0.7	None
Purple Turtle Beach	- 4.872	- 1.0	Significant
Belle Hall Beach	- 5.098	- 1.0	Significant
Toucarie Bay	- 3.628	- 0.7	Significant
Hampstead	- 2.507	- 0.5	Minor
Pointe Baptiste	- 1.705	- 0.3	None
Woodford Hill	- 0.647	- 0.1	Significant
Londonderry Beach	-18.964	- 3.8	Significant
Pagua Bay	-25.101	- 5.0	Significant
Castle Bruce	- 4.841	- 1.0	Significant
Bout Sable North	- 3.763	- 0.8	None
Bout Sable South	-12.036	- 2.4	Significant
Dubuc	- 5.316	- 1.1	Minor
Mean	- 5.158	- 1.0	

Table 3 can also be used to differentiate the erosion rates for the different coasts:

West Coast - mean erosion rate	=	-0.7m/yr (14 sites)
North Coast - mean erosion rate	=	-0.3m/yr (3 sites)
East Coast - mean erosion rate	=	-1.9m/yr (6 sites)

It is interesting to note that the erosion rate on the windward or exposed coast is nearly three times that of the rate on the west coast. The north coast appears to be the most stable.

These rates can be compared with data from the west coast of Nevis over the period 1988-1991, Cambers (1992), here the average erosion rate for the west coast was -2.8m. As with the Dominica record, the data included the effect of Hurricane Hugo. Longer term values for Barbados, however, show much lower rates. The rates measured for the west coast of Barbados over the period 1954 to 1982 were -0.2m per year (Cambers *et al.*, 1985).

Table 3 also shows those beaches which are mined for sand and/or gravel/boulders. There is no clear relationship between mining and the amount of erosion, nevertheless most of the sites experiencing the highest erosion rates are among those mined. In addition the data for Bout Sable, where the northern site is not mined and the southern site is mined, showed the following:

Bout Sable North: annual change in area	=	-3%
Bout Sable South: annual change in area	=	-7%
Bout Sable North: erosion rate	=	-0.8m/yr
Bout Sable South: erosion rate	=	-2.4m/yr

Thus the erosion at the mined site was between two and three times as great as the erosion at the unmined site.

5. CONCLUDING REMARKS

This report has presented and analysed a considerable volume of data. The data have only been analysed in a preliminary way and further work remains to be done. However, the data record provides a unique opportunity to analyse the immediate and longer term effects of two hurricanes on the coastal stability of Dominica as well as the overall trends. The picture emerging is one of erosion throughout Dominica, where already extensive sums of money are spent to stabilise and protect the coastline. Against a global picture of future sea level rise and increased hurricane frequency, it is essential that the monitoring continues to provide the necessary basis for future decisions regarding the development, utilization and preservation of the coastline of Dominica.

References

Cambers, G., Holder, T., Ross, W. 1985. *Analysis of Beach Changes in Barbados.* Coastal Conservation Project No. 2.

Cambers, G. 1992. *Analysis of Beach Changes in Nevis 1988 - 1991.* Nevis Coastal Monitoring Programme Report #2, UNESCO COMAR/COSALC-I Project.

APPENDIX I

INDIVIDUAL SITE DATA

SCOTTS HEAD ATLANTIC – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in March 1992. This site is located on Scotts Head Spit and runs from a telegraph pole towards the Atlantic Ocean. The beach consists of pebbles and stones. Table 4 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 11. This shows seasonal build-up during the summer months of May and August, and erosion during the winter months of November and March. This is the expected pattern for an exposed Atlantic facing beach. Higher winds and waves are experienced during the period December to March, thus beach erosion is likely. Seasonal changes for the years 1989 to 1992 are not so clear partly because of the infrequency of measurement in some years and partly because of severe erosion and subsequent recovery after Hurricanes Gabrielle and Hugo in 1989.

Annual Changes

Figure 12 shows a bar graph illustrating the annual changes at this site. The profile was fairly stable in 1987 and 1988. However, in 1989 there was a very significant decline. This started even before Hurricanes Gabrielle and Hugo and may partly have been due to earlier tropical storms that year. Hurricanes Gabrielle and Hugo caused very severe erosion, the profile area decreased by -28% following these two events. There was a slight recovery in the profile area in 1990 after which there was no further change.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -40% and the profile width decreased by 4.037 m or 18%. This represents an erosion rate of 0.81 m per year.

The hurricanes of 1989 caused severe erosion at this site and while there was some slight recovery, the beach did not return to its pre-hurricane size.

TABLE 4 DATA RECORD - SCOTTS HEAD ATLANTIC
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq.m.)	Profile Width (m)
13.08.87	15.738	21.353
12.11.87	17.967	22.580
14.03.88	11.208	25.153
11.05.88	17.698	23.628
17.08.88	20.111	25.795
22.11.88	16.606	22.387
14.03.89	14.184	23.424
27.06.89	11.590	19.565
---------Hurricanes Gabrielle & Hugo----------		
29.09.89	10.364	20.833
13.12.89	8.149	17.772
02.02.90	9.845	20.167
17.05.90	10.697	21.094
14.08.90	9.449	18.433
23.08.91	10.514	19.046
10.12.91	8.249	18.660
09.03.92	10.047	17.930

DATA SUMMARY SCOTTS HEAD ATLANTIC - 1987 - 1992

Year	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m)
1987	16.853		21.967
1988	16.406	- 3	24.241
1989pre HH&G	12.887	- 21	21.495
1989postHH&G	9.257	- 28	19.303
1990	9.997	+ 8	19.898
1991	10.103	+ 1	18.853
1992	10.047	- 1	17.930

FIGURE 11

Scotts Head (Atlantic)
Seasonal Changes 1988

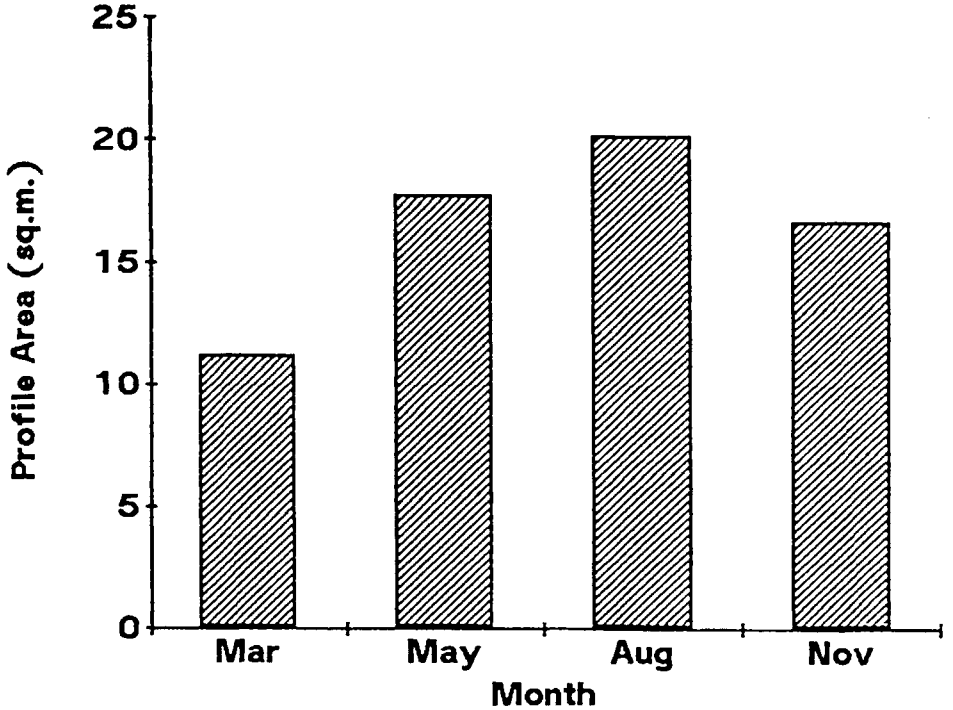
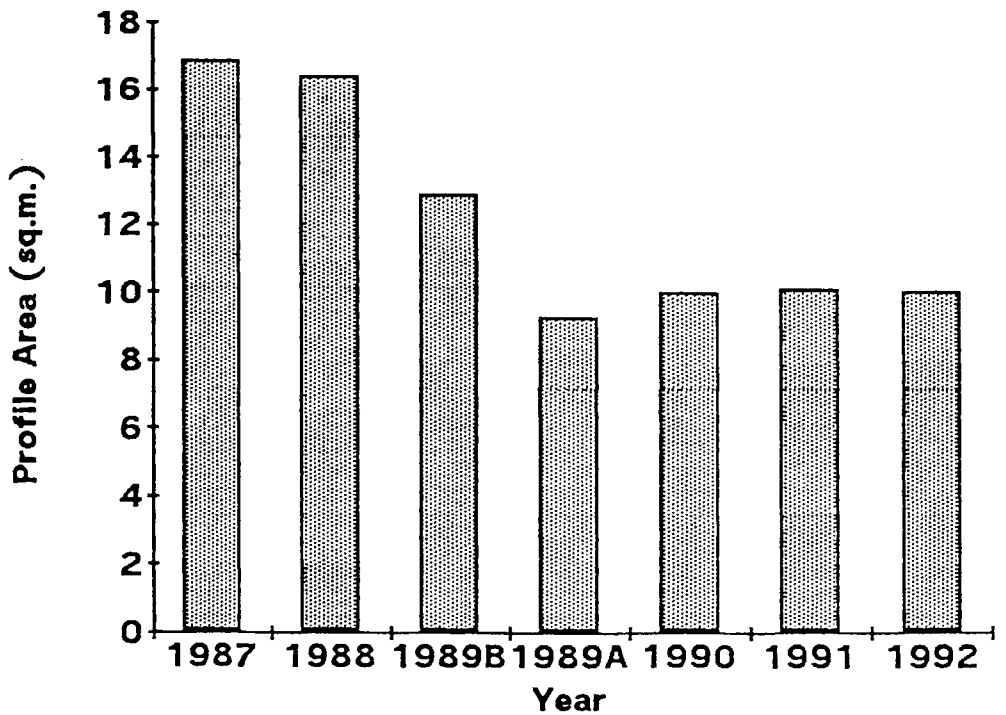


FIGURE 12

Scotts Head (Atlantic)
Annual Changes 1987-1992



SCOTTS HEAD CARIBBEAN – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in March 1992. This site is located on Scotts Head Spit and runs from the same telegraph pole as for Scotts Head Atlantic but in the opposite direction towards the Caribbean Sea. Thus the wave energy at this site is much lower than for Scotts Head Atlantic. The beach consists of pebbles and stones. Table 5 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 13. This shows seasonal build-up during the summer months of May and August with significant erosion in March, which is during the winter groundseas period. During this period leeward beaches often show erosion due to high swells originating from storms in the Northern Atlantic Ocean. Seasonal changes for the years 1989 to 1992 are not so clear partly because of the infrequency of measurement in some years and partly because of severe erosion and subsequent recovery after Hurricanes Gabrielle and Hugo in 1989.

Annual Changes

Figure 14 shows a bar graph illustrating the annual changes at this site. This profile has shown a very steady decline over the six-year period. Between 1987 and 1989 there was a regular if small decrease in profile area from year to year. Then in 1989 there was a significant drop due to the effect of the two hurricanes. Following 1989, there was a very small recovery in 1990, however, in 1991 and 1992 the size of the beach continued to decrease.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -47% and the profile width decreased by 5.489 m or 47%. This represents an erosion rate of 1.1 m per year.

There has been consistent erosion at this site and this has been accentuated by the hurricanes of 1989.

Combining the data for Scotts Head Atlantic and Scotts Head Caribbean shows that the spit at this point has become narrower by 9.526 m or 28%. This could have serious implications for the future stability of this barrier.

TABLE 5 DATA RECORD - SCOTTS HEAD CARIBBEAN
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq.m.)	Profile Width (m)
13.08.87	10.705	11.900
12.11.87	10.370	11.233
14.03.88	7.603	9.783
11.05.88	10.634	18.645
17.08.88	10.313	12.763
22.11.88	9.793	12.204
14.03.89	9.535	11.079
26.06.89	8.199	9.504
----------Hurricanes Gabrielle & Hugo----------		
26.09.89	6.887	6.944
13.12.89	7.123	7.843
08.02.90	7.709	9.340
17.05.90	7.421	8.952
14.08.90	6.156	6.880
23.08.91	6.349	7.201
10.12.91	6.099	7.036
09.03.92	5.578	6.078

DATA SUMMARY - SCOTTS HEAD CARIBBEAN - 1987 TO 1992

Year	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m)
1987	10.538		11.567
1988	9.586	-10	13.349
1989preH.Hug	8.867	- 8	10.292
1989postH.Hug	7.005	-21	7.394
1990	7.095	- 1	7.095
1991	6.224	-12	7.119
1992	5.578	-10	6.078

FIGURE 13

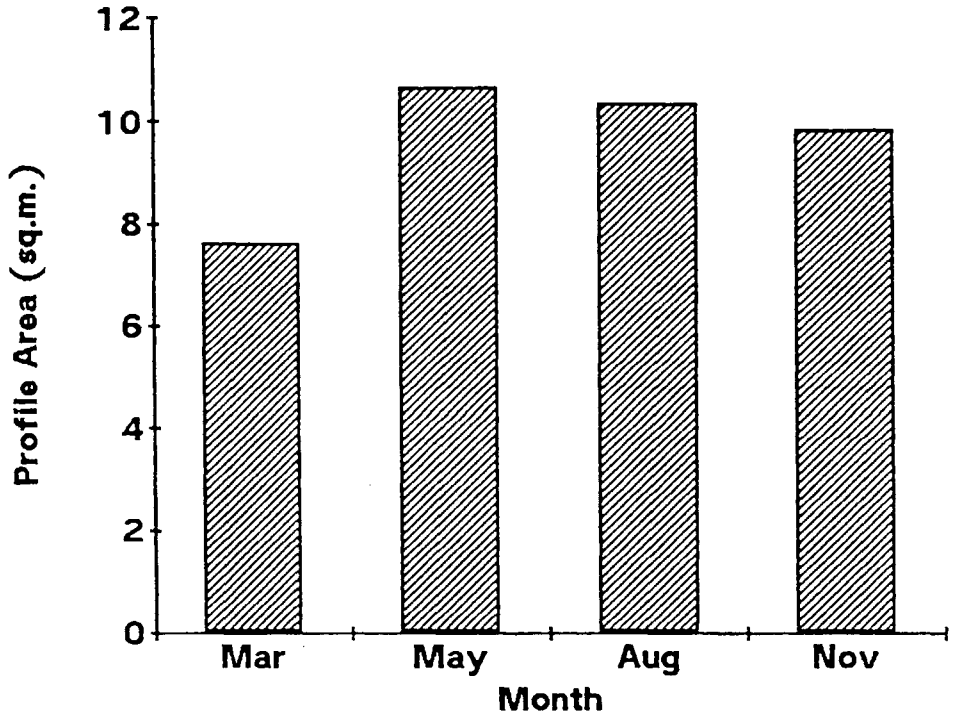
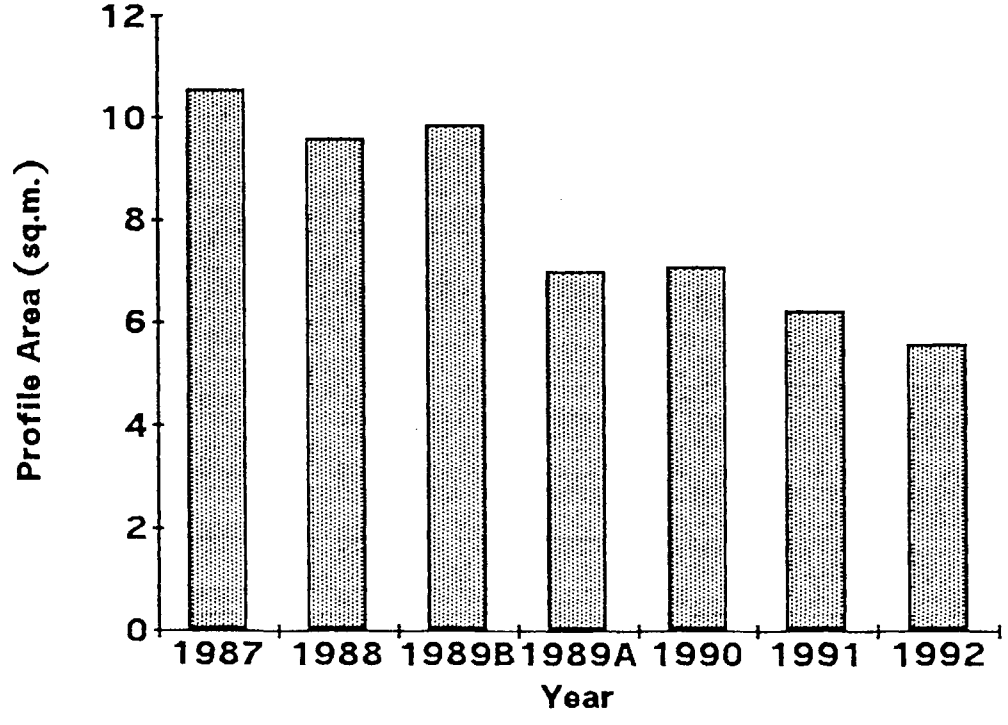


FIGURE 14



ROSEAU BAYFRONT - BEACH CHANGES 1989 TO 1991

This profile was started in June 1989 at the request of persons conducting the Bayfront Feasibility Project. The site is located between the Old Jetty and the Market, in front of the Dexia Building, and consists of sand and boulders. Table 6 shows the data for this site.

Seasonal Changes

The data were not collected regularly enough to show seasonal changes, although it is expected that this site would show the normal pattern for the west coast of summer accretion and erosion during the winter months.

Annual Changes

Figure 15 shows the annual changes for this site in the form of a bar graph. There was some slight accretion following Hurricane Hugo, when boulders were thrown up onto the beach. Apart from this the beach has remained stable.

A comparison of the 1989 data with the 1991 data shows that the profile area increased by +4% and the profile width decreased by 0.446 m or -2%. This represents an erosion rate of -0.223 m per year. (The fact that the area increased slightly and the width decreased indicates the beach slope steepened and this is usually indicative of erosion).

TABLE 6 DATA RECORD ROSEAU BAYFRONT
JUNE 1989 TO SEPTEMBER 1991

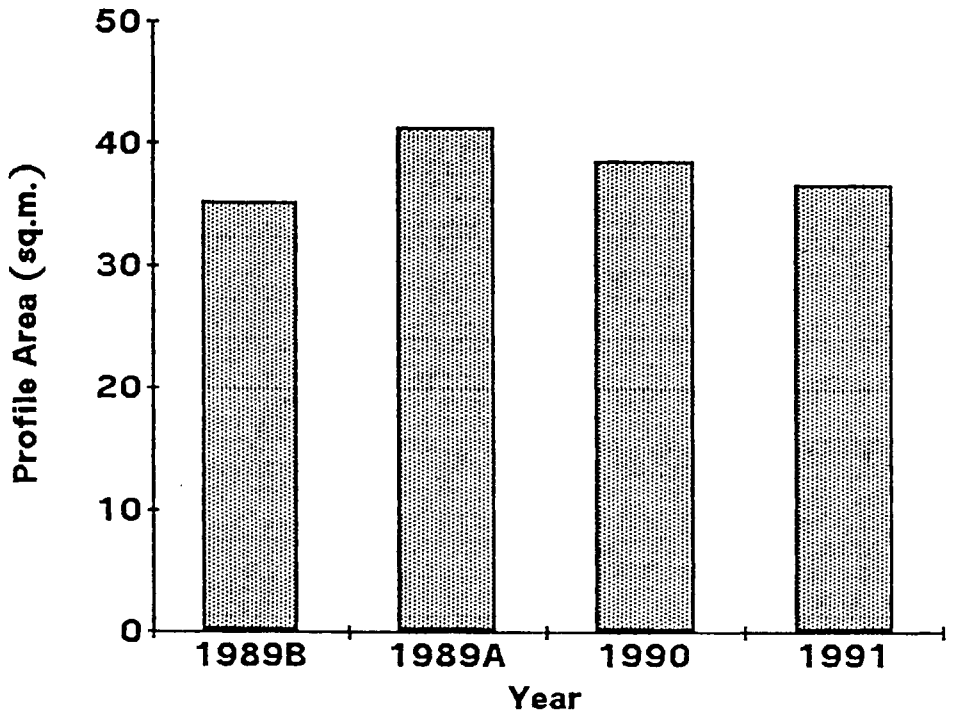
Date	Profile Area (sq.m.)	Profile Width (m.)
27.06.89	35.116	25.340
----------Hurricane Hugo----------		
26.09.89	43.346	27.316
13.12.89	39.115	24.994
12.03.90	39.710	28.559
17.05.90	37.286	26.545
04.09.91	36.559	24.894

DATA SUMMARY ROSEAU BAYFRONT 1989 - 1991

Year	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m.)
1989preHH	35.116		25.340
1989postHH	41.231	+17	26.155
1990	38.498	- 7	27.552
1991	36.559	- 5	24.894

FIGURE 15

Roseau Bayfront
Annual Changes 1989-1991



POTTERSVILLE – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in March 1992. This site is located on the west or leeward coast just north of Roseau. The beach consists mainly of sand at this site. Table 7 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1987 and 1988 is shown in Figure 16. This shows seasonal build-up during the summer months of May and August with significant erosion in November and March, which is during the winter groundseas period. During this period leeward beaches often show erosion due to high swells originating from storms in the Northern Atlantic Ocean. Seasonal changes for the years 1989 to 1992 are not so clear partly because of the infrequency of measurement in some years and partly because of severe erosion and subsequent recovery after Hurricanes Gabrielle and Hugo in 1989.

Annual Changes

Figure 17 shows a bar graph illustrating the annual changes at this site. This profile has shown fairly consistent values for the period 1987 to mid-1989. After Hurricanes Gabrielle and Hugo there was significant erosion. However, the profile showed recovery in 1990 and by 1991 it had returned to pre-hurricane levels and by 1992 the beach was wider than in 1987.

A comparison of the 1987 data with the 1992 data shows that the profile area increased by +22% and the profile width increased by 4.635 m or +18%. This represents an accretion rate of +0.9 m per year.

TABLE 7 DATA RECORD - POTTERSVILLE
AUGUST 1987 TO FEBRUARY 1992

Year	Profile Area (sq.m.)	Profile Width (m.)
14.08.87	42.922	26.869
12.11.87	36.985	23.717
04.03.88	36.004	25.006
31.05.88	44.943	28.716
22.11.88	31.961	21.271
27.06.89	40.028	24.609
---------Hurricanes Gabrielle & Hugo----------		
26.09.89	33.103	22.117
13.12.89	31.815	22.055
12.03.90	37.418	25.555
17.05.90	36.013	24.119
04.09.91	41.955	26.212
10.12.91	45.517	27.271
09.03.92	48.900	29.928

DATA SUMMARY - POTTERSVILLE - 1987 - 1992

Year	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m.)
1987	39.954		25.293
1988	37.636	- 6	24.998
1989pre HH&HG	40.028	+ 6	24.609
1989postHH&HG	32.459	- 19	22.086
1990	36.716	+ 13	24.837
1991	43.736	+ 19	26.742
1992	48.900	+ 12	29.928

FIGURE 16

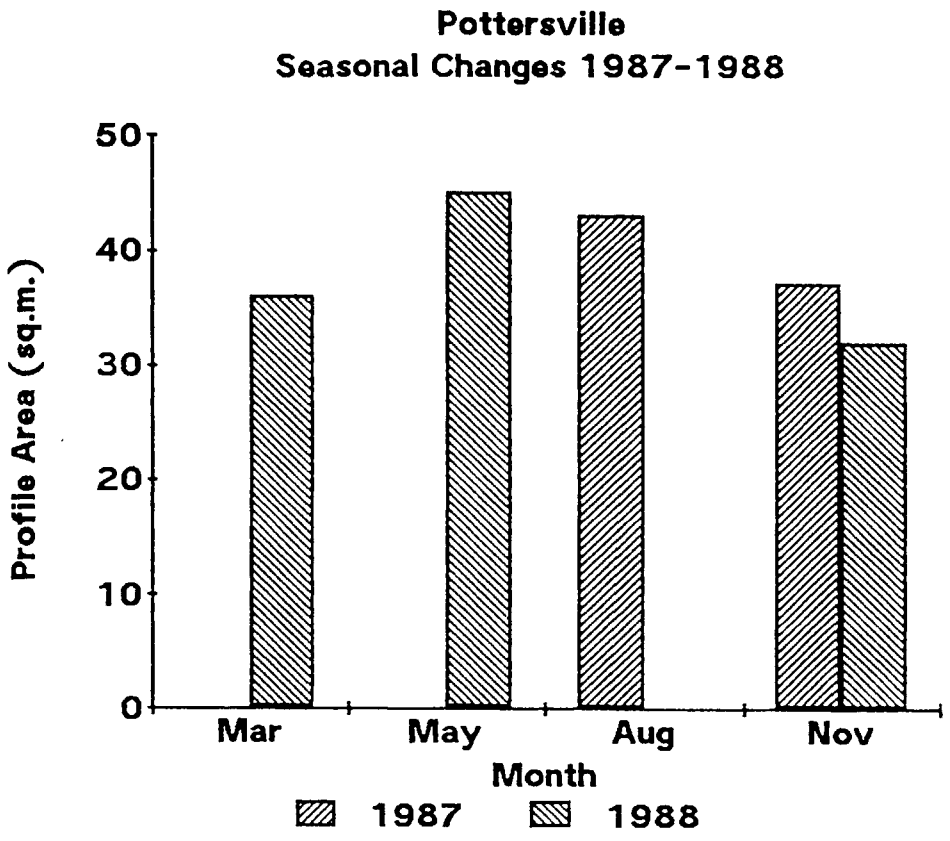
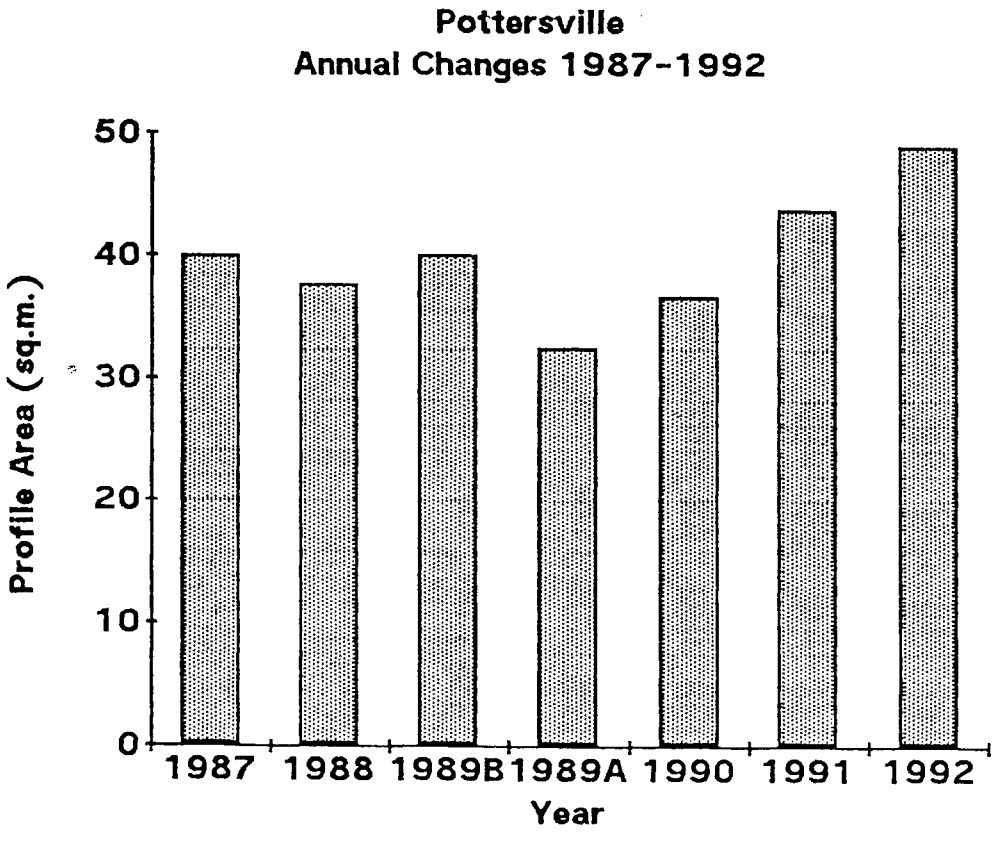


FIGURE 17



WOODBRIDGE BAY – BEACH CHANGES 1987 - 1990

This profile was started in August 1987. It is located just south of the Deepwater Harbour, and the profile was discontinued in May 1990 due to the expansion of the the port. The beach consisted of sand. Table 8 shows the data for this site.

Seasonal Changes

Figure 18 shows a bar graph illustrating the seasonal changes for 1988-1989. This shows the expected general pattern of higher values in August and lower values in March and December. (The value for December 1988 was somewhat higher that expected).

Annual Changes

Figure 19 shows a bar graph of the annual changes up to 1990. The profile was fairly stable and showed slight accretion until Hurricane Hugo in 1989. There was significant erosion after this event, and the beach had not recovered up to the time the profile was discontinued.

A comparison of the 1987 data with the 1990 data shows that the profile area decreased by -11 % and the profile width decreased by 3.501 m or -11%. This represents an erosion rate of -1.167m per year.

TABLE 8 DATA RECORD WOODBRIDGE BAY
AUGUST 1987 - MAY 1990

Date	Profile Area (sq.m.)	Profile Width (m.)
13.08.87	63.792	35.306
12.11.87	58.624	30.528
04.03.88	58.906	29.308
18.05.88	63.774	32.129
17.08.88	72.171	37.907
01.12.88	71.010	37.601
27.06.89	64.946	34.743
----------Hurricane Hugo----------		
26.09.89	51.621	29.826
13.12.89	59.874	31.851
12.03.90	59.868	29.803
17.05.90	57.520	29.028

DATA SUMMARY WOODBRIDGE BAY 1987 - 1990

Year	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m.)
1987	61.177		32.917
1988	66.465	+ 8.6	34.236
1989preHH	64.946	- 2.3	34.743
1989postHH	55.748	-14.2	30.839
1990	58.694	+ 5.3	29.416

FIGURE 18

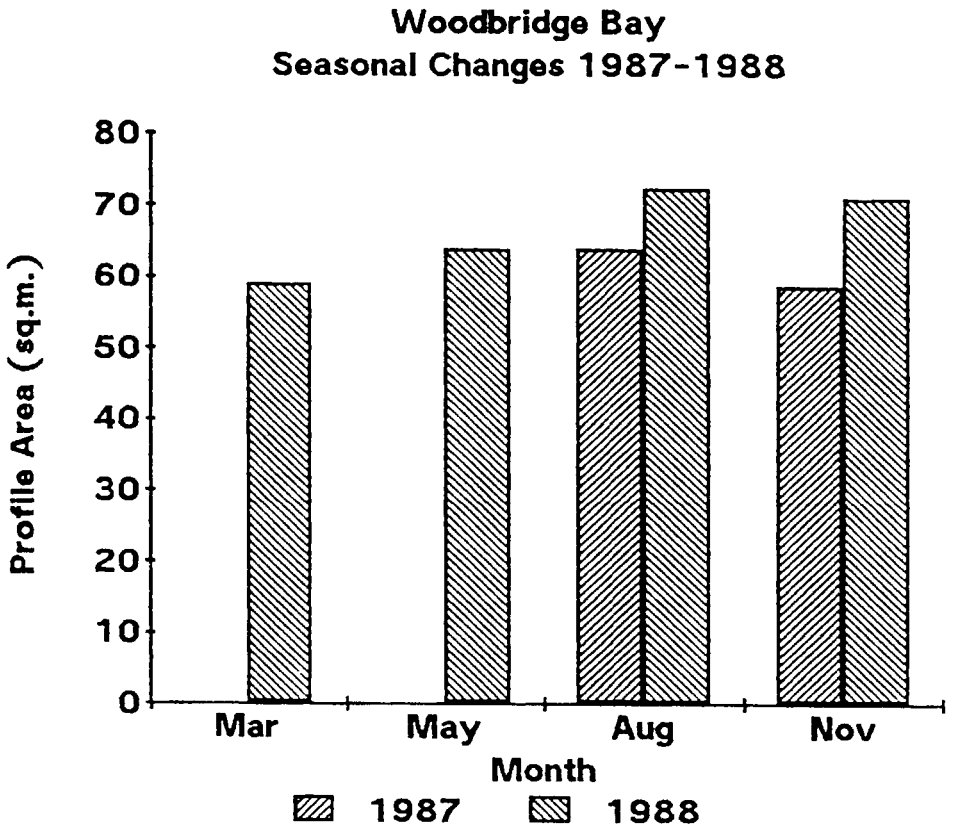
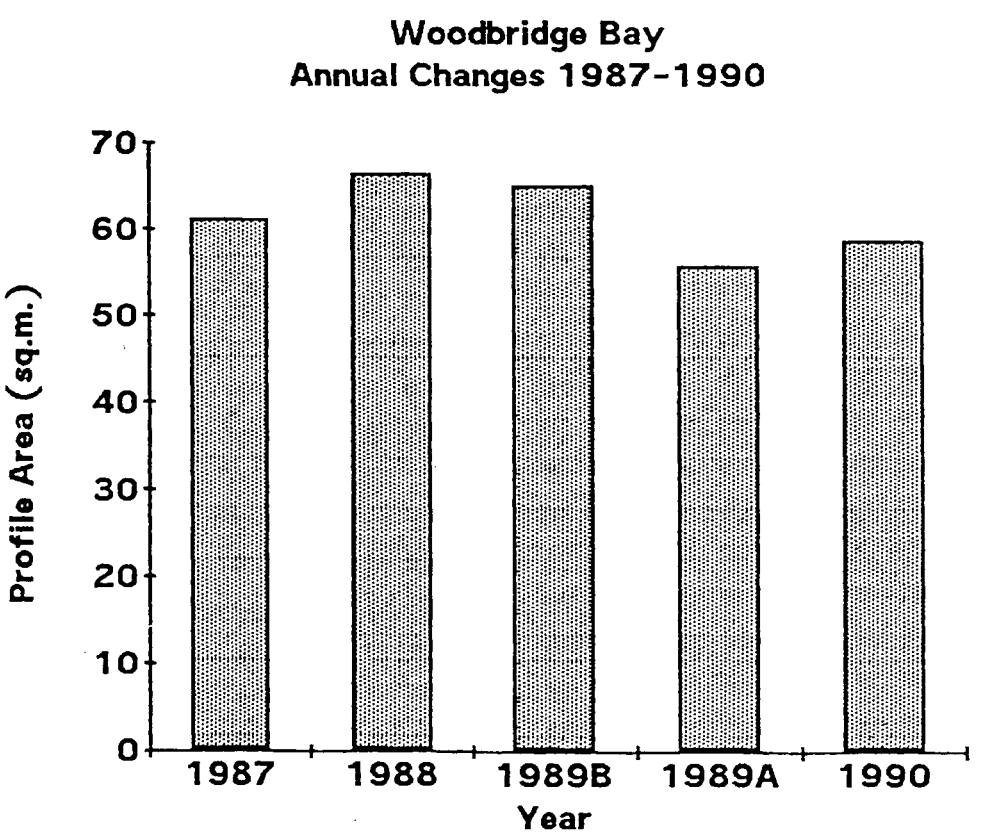


FIGURE 19



ROCKAWAY #1 – BEACH CHANGES 1987 TO 1991

This profile was started in August 1987, and was discontinued in September 1991 because it was difficult to get to the reference point. This site is located on the west or leeward coast north of Roseau. The beach consists of sand in the main, however, during winter months the sand is often replaced by stones. Table 9 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1987 and 1988 is shown in Figure 20. The seasonal changes during these two years are not as significant as at many other west coast beaches. The graph shows a slight erosion trend in November, however, during the rest of the year the profile area remained very consistent. As previously mentioned the most obvious seasonal change at this site is that during the winter months the beach becomes very stony. Seasonal changes for the years 1989 to 1991 are not very obvious partly because of the infrequency of measurement in some years and partly because of severe erosion and subsequent recovery after Hurricanes Gabrielle and Hugo in 1989.

Annual Changes

Figure 21 shows a bar graph illustrating the annual changes at this site. This profile has shown fairly consistent values for the period 1987 to mid 1989. After Hurricanes Gabrielle and Hugo there was significant accretion. This is very unusual in the context of the behaviour of other sites and is somewhat difficult to explain. At the beginning of 1990 some rubble was dumped near the reference point on the profile line and this caused the profile area to increase. Table 6 shows the actual area values for 1990/1991 and also the adjusted values, with the man-made material subtracted from the computation. As can be seen from the adjusted values, there was a slight erosion trend after the hurricane accretion. (Figure 12 shows the adjusted values for 1990 and 1991).

A comparison of the 1987 data with the 1991 adjusted data shows that the profile area increased by +18% and the profile width increased by 1.274 m or +9%. This represents an accretion rate of +0.3 m per year.

TABLE 9 DATA RECORD - ROCKAWAY #1
AUGUST 1987 - SEPTEMBER 1991

Date	Profile Area (sq.m.)	Profile Width (m.)
14.08.87	17.117	13.949
02.12.87	16.426	15.037
08.03.88	17.282	15.213
18.05.88	17.355	16.829
11.08.88	17.560	17.868
22.11.88	14.719	14.086
17.03.89	17.350	17.800
15.06.89	14.813	12.829
10.08.89	15.034	12.632
----------Hurricane Gabrielle----------		
14.09.89	18.428	15.966
----------Hurricane Hugo----------		
26.09.89	19.472	16.582
29.11.89	23.393	15.332
12.03.90	26.623 (21.762)	18.090
09.05.90	25.545 (20.684)	17.797
22.08.90	25.429 (20.568)	15.803
15.02.91	26.752 (21.891)	18.097
14.09.91	22.713 (17.852)	13.436
----------Profile Discontinued----------		

DATA SUMMARY ROCKAWAY #1 - 1987 - 1991

Date	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m)
1987	16.772		14.493
1988	16.729	0	15.999
1989preHH	16.406	- 2	14.807
1989postHH	21.432	+31	15.957
1990	25.860(21.004)	+21 (-2)	17.230
1991	24.733(19.872)	- 4 (-5)	15.767

Figures in brackets show adjusted values after the rubble dumped by man was subtracted from the calculations.

FIGURE 20

Rockaway #1
Seasonal Changes 1987-1988

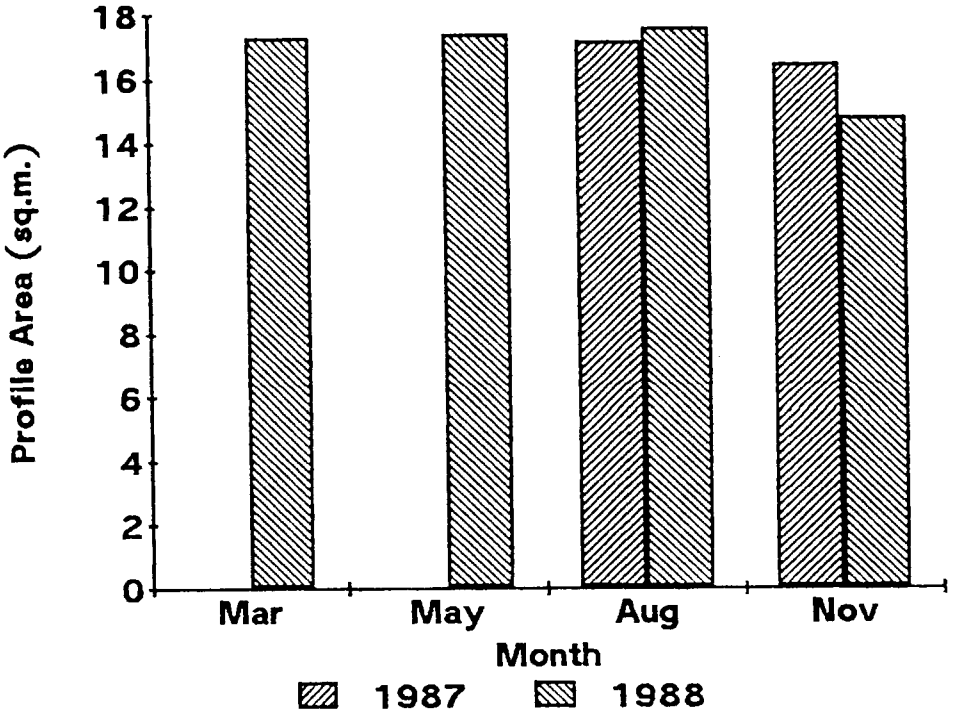
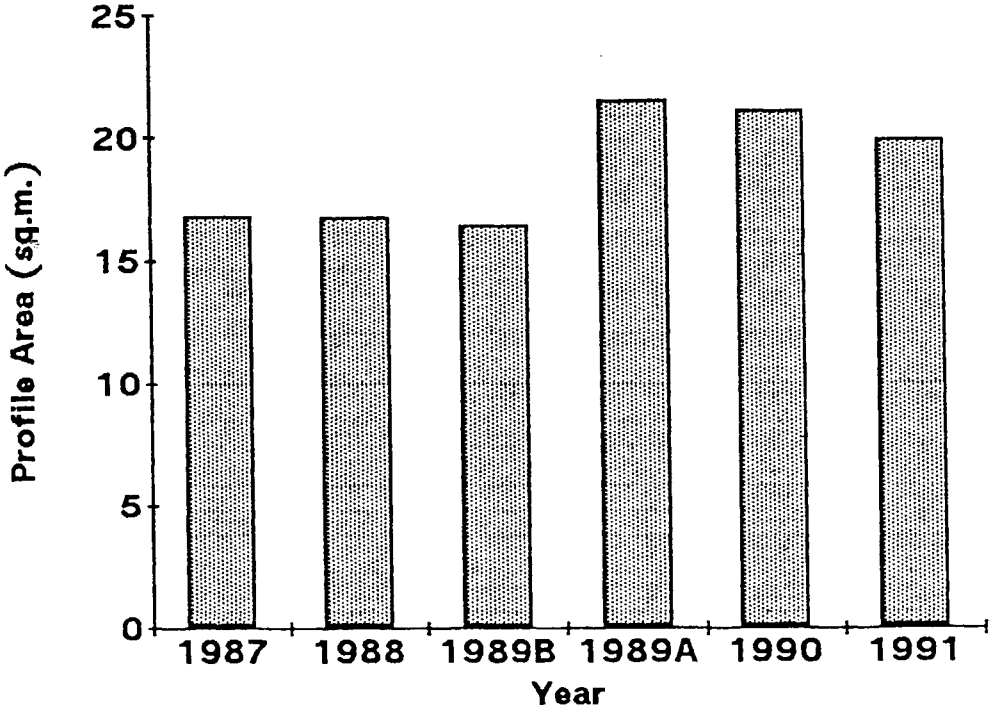


FIGURE 21

Rockaway #1
Annual Changes 1987-1991



ROCKAWAY #2 – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in March 1992. This site is located on the west or leeward coast north of Roseau and just north of Rockaway #1. The beach is located south of the Boeri River and the offshore zone receives a lot of slurry from a nearby pumice and rock-crushing operation. The beach consists of fine sand. Table 10 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1987 and 1988 is shown in Figure 22. This shows the expected seasonal changes for a west coast beach with erosion during November and March and accretion during the summer months particularly August. The erosion is associated with high swells emanating from intense North Atlantic storms during the winter months. Seasonal changes for the years 1989 to 1992 are not so obvious partly because of the infrequency of measurement in some years and partly because of severe erosion and subsequent recovery after Hurricanes Gabrielle and Hugo in 1989.

Annual Changes

Figure 23 shows a bar graph illustrating the annual changes at this site. This profile showed fairly consistent values before the 1989 hurricanes. There was significant erosion following Hurricane Hugo in 1989 when the usual sand beach was replaced with stones. The beach at this site showed some recovery between 1990 and 1992, however, the beach profile never regained its pre-hurricane size.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -36% and the profile width decreased by 12.446 m or -40%. This represents an erosion rate of -2.5 m per year.

TABLE 10 DATA RECORD - ROCKAWAY #2
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq.m.)	Profile Width (m.)
14.08.87	37.051	33.028
02.12.87	30.215	28.453
08.03.88	13.061	11.275
13.05.88	27.371	29.589
11.08.88	44.954	38.943
23.11.88	29.133	31.538
17.03.89	31.660	26.482
15.06.89	32.770	30.627
10.08.89	33.022	30.098
----------Hurricane Gabrielle----------		
14.09.89	31.700	27.388
----------Hurricane Hugo----------		
26.09.89	20.555	17.331
29.11.89	21.068	16.012
12.03.90	18.234	17.074
09.05.90	16.186	13.468
22.08.90	22.820	18.280
04.09.91	30.680	24.743
10.12.91	23.624	20.838
09.03.92	21.441	18.296

DATA SUMMARY ROCKAWAY #2 - 1987 - 1992

Date	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m.)
1987	33.633		30.741
1988	28.630	-15	27.836
1989preHH	32.288	+13	28.649
1989postHH	20.812	-36	16.672
1990	19.080	- 8	16.274
1991	27.152	+42	22.791
1992	21.440	-21	18.295

FIGURE 22

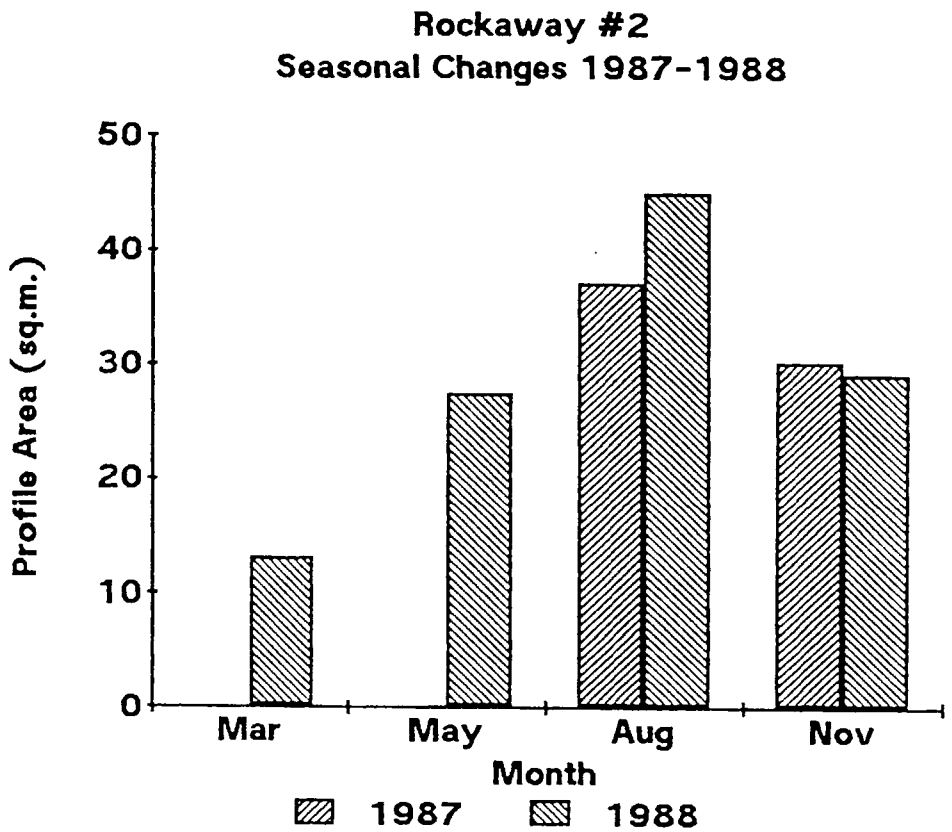
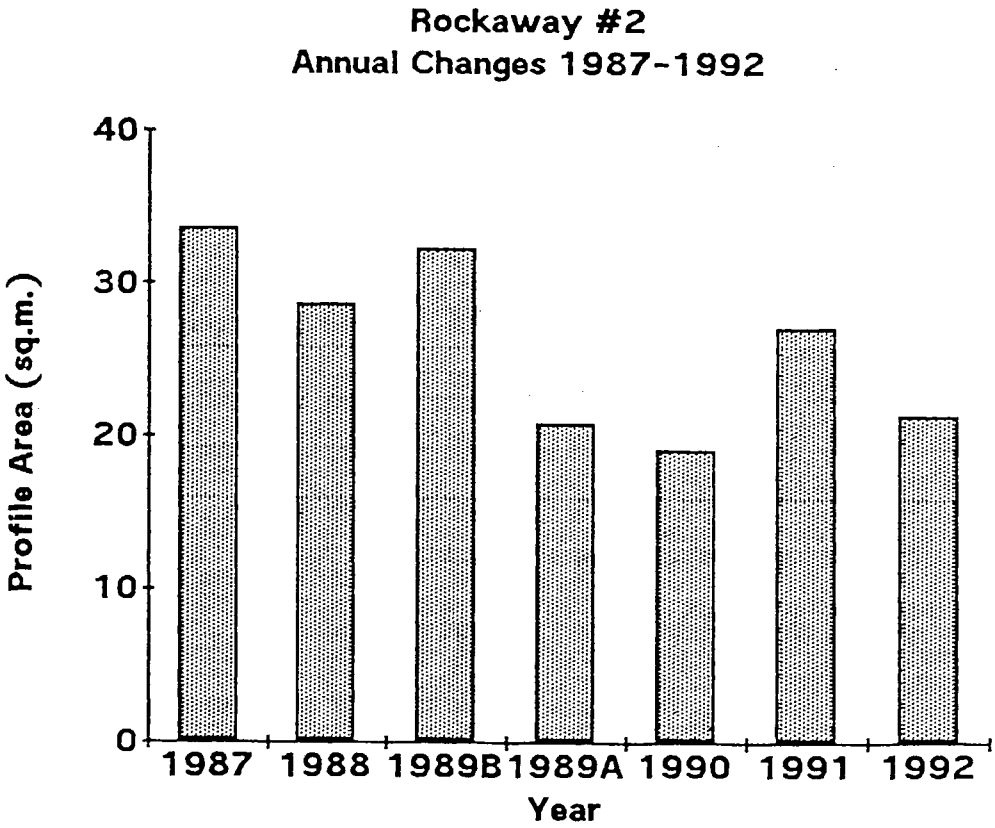


FIGURE 23



DONKEY BEACH – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in February 1992. This site is located on the west or leeward coast near Canefield. The beach consists of sand. Table 11 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 24. This shows the expected seasonal changes for a west coast beach with erosion during December and accretion during the summer months around August. The seasonal changes, however, are not as well defined as at some other west coast sites. The erosion is associated with high swells emanating from intense North Atlantic storms during the winter months. Seasonal changes for the years 1989 to 1992 are not so obvious partly because of the infrequency of measurement in some years and partly because of severe erosion and subsequent recovery after Hurricanes Gabrielle and Hugo in 1989.

Annual Changes

Figure 25 shows a bar graph illustrating the annual changes at this site. This profile showed fairly consistent values before the 1989 hurricanes. Then there was significant erosion following Hurricane Hugo in 1989. The beach at this site showed some recovery in 1990, but since then there has been a steady decline. It is significant to note that the beach never returned to its pre-hurricane levels.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -13% and the profile width decreased by 3.870 m or -14%. This represents an erosion rate of -0.8 m per year.

TABLE 11 DATA RECORD - DONKEY BEACH
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq.m.)	Profile Width (m)
14.08.87	50.528	27.749
02.12.87	50.415	28.643
08.03.88	54.934	30.445
18.05.88	50.183	29.027
11.08.88	57.871	31.712
01.12.88	47.611	27.671
17.03.89	51.337	29.129
15.06.89	48.670	29.461
10.08.89	45.153	27.573
----------Hurricane Gabrielle----------		
14.09.89	43.697	26.440
----------Hurricane Hugo----------		
27.09.89	36.957	19.592
29.11.89	44.981	24.771
12.03.90	50.860	32.128
09.05.90	43.190	26.657
22.08.90	44.436	25.926
04.09.91	44.287	24.991
10.12.91	46.550	26.764
25.02.92	43.914	24.326

DATA SUMMARY DONKEY BEACH - 1987 - 1992

Date	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m.)
1987	50.472		28.196
1988	52.650	+ 4	29.713
1989preHH	47.214	-10	28.151
1989postHH	40.969	-13	22.182
1990	46.162	+13	28.237
1991	45.419	- 2	25.878
1992	43.914	- 3	24.326

FIGURE 24

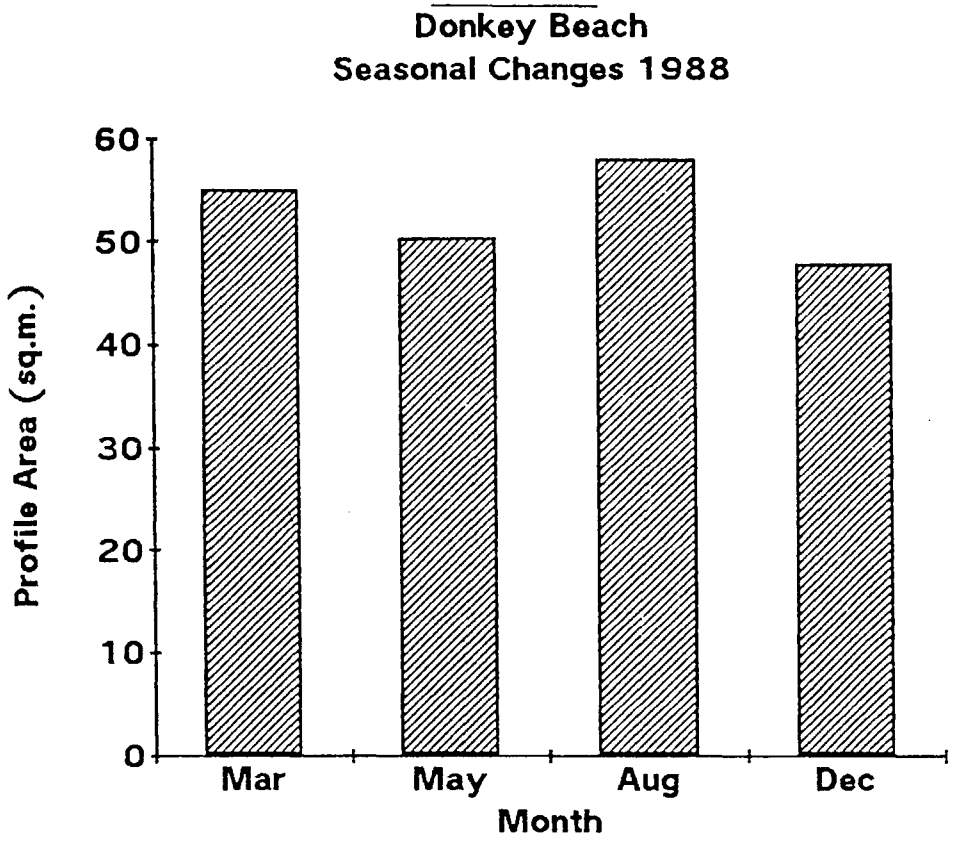
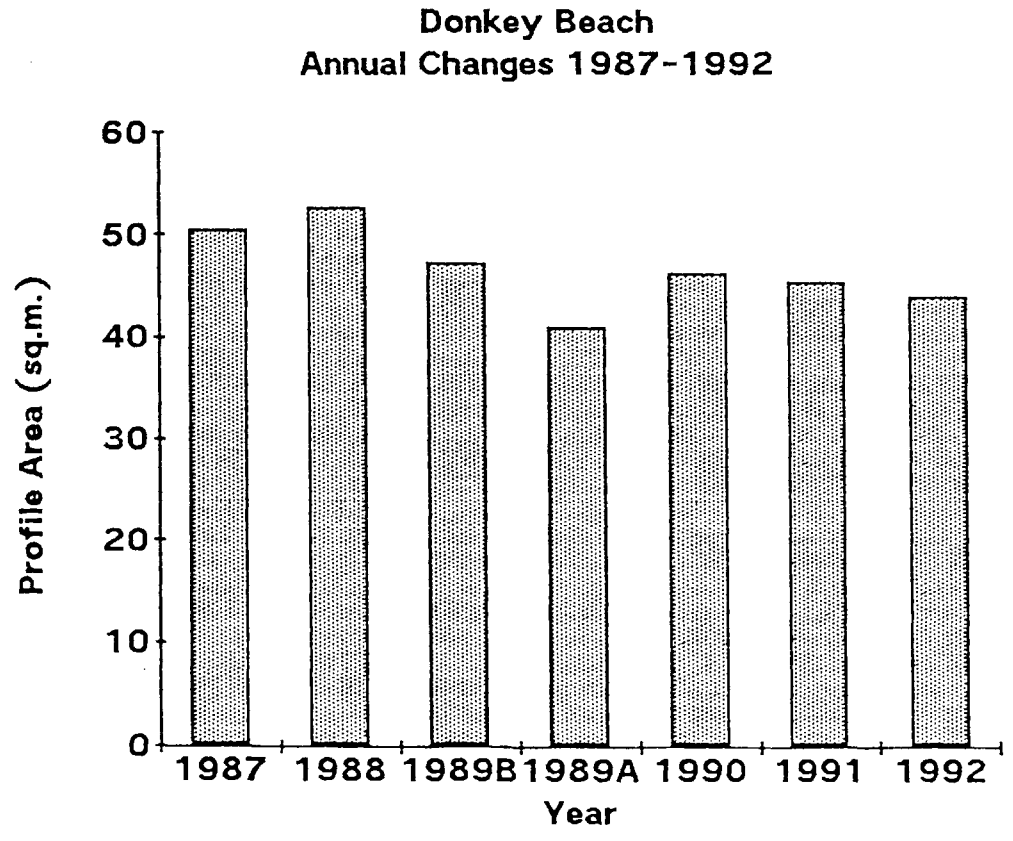


FIGURE 25



MERO BEACH – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in February 1992. However, a new profile had to be established in December 1987 due to the loss of the original reference mark. This site is located on the west or leeward coast. There is a hotel located behind this beach. The beach consists of sand. Table 12 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 26. This shows the expected seasonal changes for a west coast beach with erosion during the winter month of November and accretion during the rest of the year. The erosion is associated with high swells emanating from intense North Atlantic storms during the winter months. Seasonal changes for the years 1989 to 1992 are not so obvious partly because of the infrequency of measurement in some years and partly because of severe erosion and subsequent recovery after Hurricanes Gabrielle and Hugo in 1989.

Annual Changes

Figure 27 shows a bar graph illustrating the annual changes at this site. The value for 1987 represents only one reading in December. Between 1988 and mid-1989 the profile area showed some decrease. Following Hurricane Hugo in September 1989, there was significant erosion. The beach profile showed some recovery in 1990 and since then it has remained at nearly the same value. It is significant to note that the beach never returned to its pre-hurricane levels.

A comparison of the 1988 data with the 1992 data shows that the profile area decreased by -19% and the profile width decreased by 1.181 m or -6%. This represents an erosion rate of -0.3 m per year. (The 1988 data has been used as the baseline year at this site because the 1987 data record had only one winter value, whereas at other sites the 1987 average represented one summer and one winter value).

TABLE 12 DATA RECORD - MERO BEACH
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq.m)	Profile Width (m)
14.08.87	40.739	21.889
----------new profile established----------		
02.12.87	18.580	14.882
09.03.88	33.775	22.015
18.05.88	34.136	23.352
11.08.88	30.784	20.771
23.11.88	20.340	16.003
16.03.89	30.892	22.863
15.06.89	26.107	18.114
10.08.89	21.833	16.856
----------Hurricane Gabrielle----------		
14.09.89	20.758	16.076
----------Hurricane Hugo ----------		
27.09.89	15.086	14.005
20.10.89	14.208	13.204
29.11.89	13.906	12.161
05.01.90	19.329	15.726
22.02.90	23.676	18.326
09.05.90	25.028	20.341
12.09.90	26.673	20.466
04.09.91	25.675	20.261
29.11.91	21.828	17.586
25.02.92	24.114	19.377

DATA SUMMARY - MERO BEACH - 1987 TO 1992

Year	Mean Profile Area (sq.m)	% Change in Profile Area	Mean Profile Width (m)
1987	18.580		14.882
1988	29.759	+ 60	20.558
1989pre H.Hugo	24.898	- 16	18.477
1989postH.Hugo	14.400	- 42	13.123
1990	23.677	+ 64	18.715
1991	23.752	0	18.924
1992	24.114	+ 2	19.377

FIGURE 26

Mero Beach
Seasonal Changes 1988

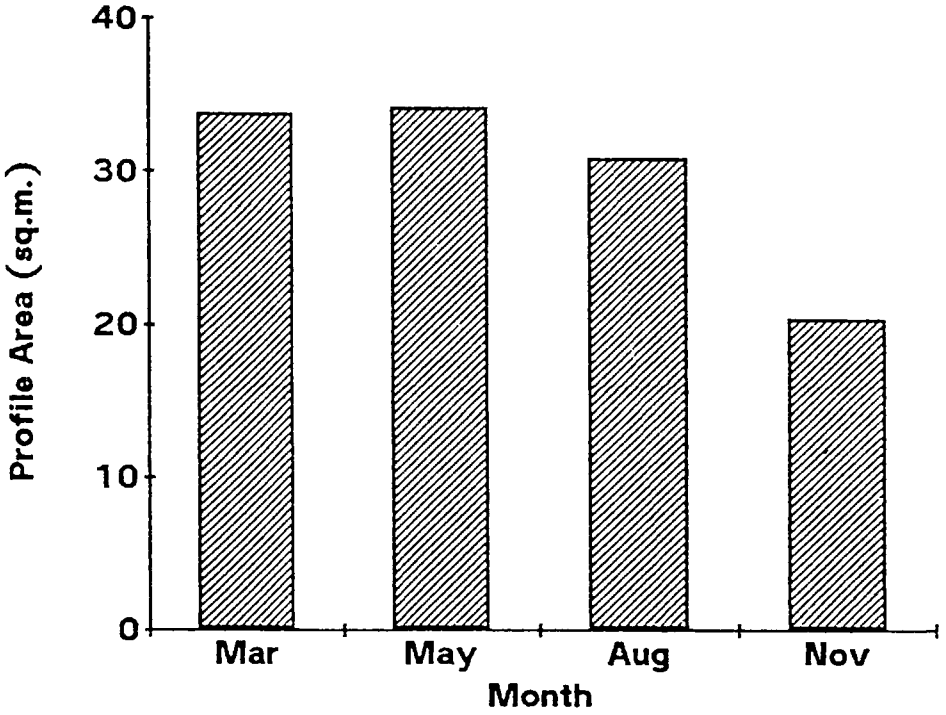
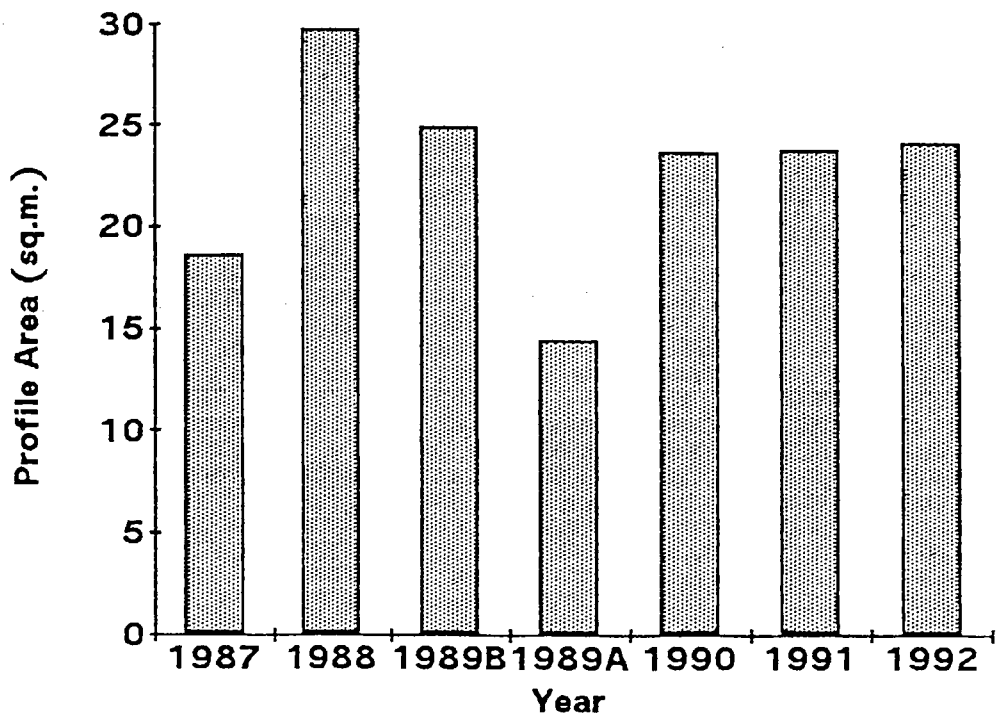


FIGURE 27

Mero Beach
Annual Changes 1987-1992



BATALIE BEACH – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in February 1992. This site is located on the west or leeward coast south of Batalie River. The beach consists of sand. Table 13 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 28. This shows the expected seasonal changes for a west coast beach with erosion during the winter month of November and accretion particularly during August. (May also showed erosion which is somewhat atypical). The erosion is associated with high swells emanating from intense North Atlantic storms during the winter months. Seasonal changes for the years 1989 to 1992 are not so obvious partly because of the infrequency of measurement in some years and partly because of severe erosion and subsequent recovery after Hurricanes Gabrielle and Hugo in 1989.

Annual Changes

Figure 29 shows a bar graph illustrating the annual changes at this site. The mean values for 1987 and 1988 were fairly consistent, there was significant erosion in the first half of 1989. But then following Hurricane Hugo in September 1989 there was significant accretion. However, since 1990 the site has shown slow, but steady erosion. The accretion following Hurricane Hugo is somewhat difficult to explain. Despite all these changes a comparison of the 1987 and 1992 values shows little change, thus over this period, despite fluctuations, the beach profile has remained stable.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -5% and the profile width decreased by 1.668 m or -5%. This represents an erosion rate of -0.3 m per year.

TABLE 13 DATA RECORD - BATALIE BEACH
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq.m.)	Profile Width (m.)
14.08.87	43.218	36.867
02.12.87	44.487	37.159
08.03.88	45.900	38.804
18.05.88	37.179	29.701
11.08.88	62.660	42.296
23.11.88	41.346	35.457
17.03.89	41.935	36.920
15.06.89	37.439	34.024
10.08.89	38.281	34.452
----------Hurricane Gabrielle----------		
14.09.89	35.890	33.111
----------Hurricane Hugo----------		
27.09.89	44.402	37.762
29.11.89	52.222	34.745
22.02.90	53.323	41.328
09.05.90	46.702	40.959
12.09.90	33.375	27.559
13.02.91	47.632	39.002
14.09.91	40.243	36.191
29.11.91	43.780	37.835
25.02.92	41.573	35.345

DATA SUMMARY BATALIE BEACH 1987 - 1992

Date	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m.)
1987	43.853		37.013
1988	46.771	+ 7	36.565
1989preHH	38.386	-18	34.627
1989postHH	48.262	+26	36.253
1990	44.467	- 8	36.615
1991	43.885	- 1	37.676
1992	41.573	- 5	35.345

FIGURE 28

Batalie Beach
Seasonal Changes 1988

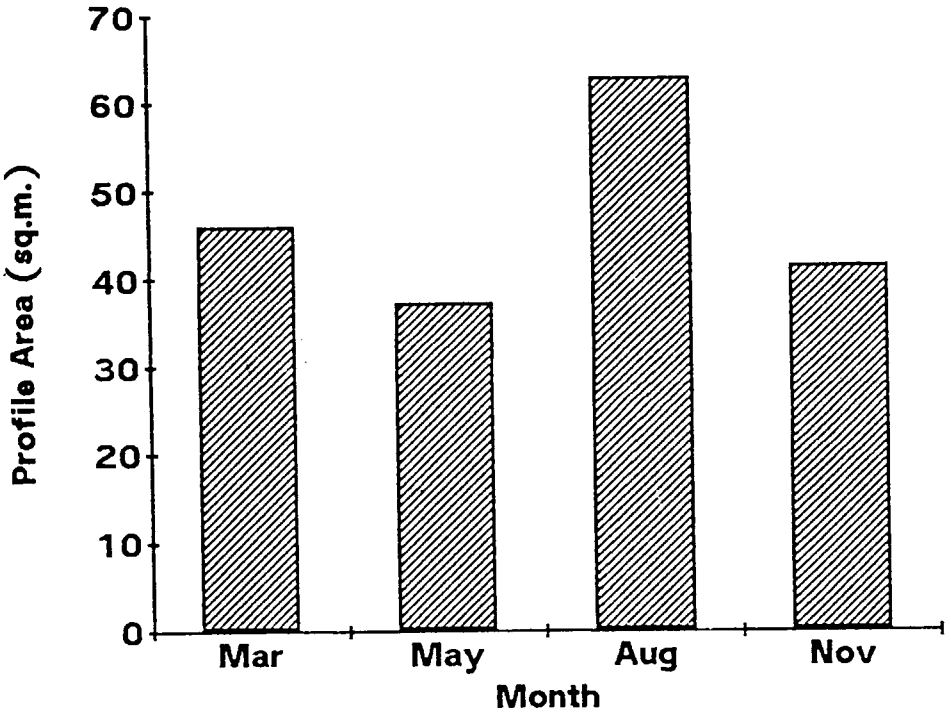
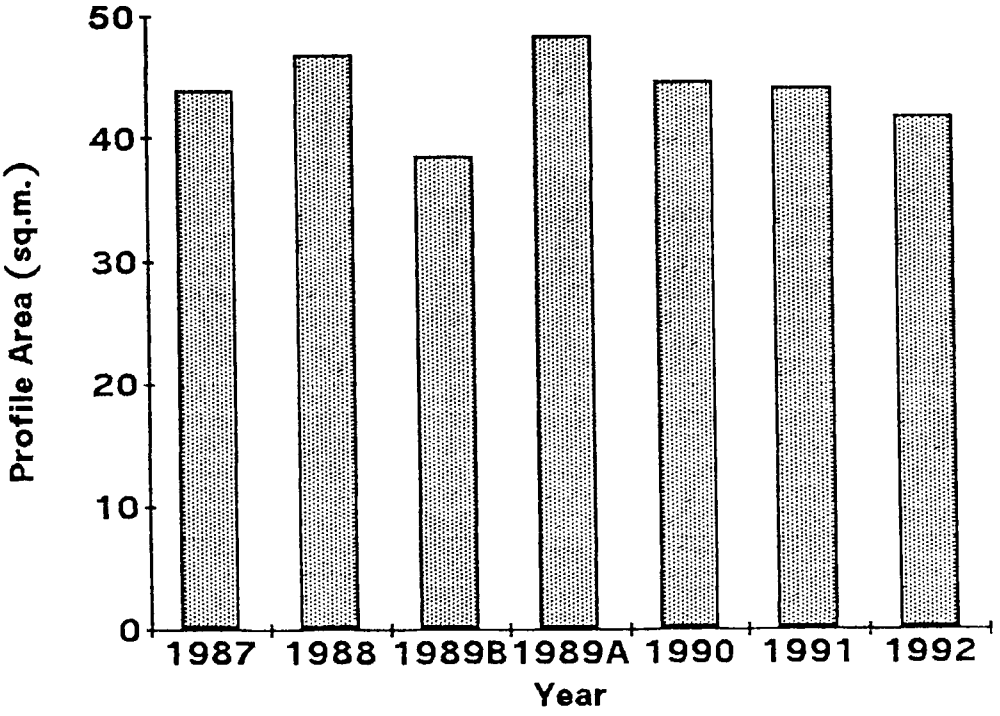


FIGURE 29

Batalie Beach
Annual Changes 1987-1992



COCONUT BEACH – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in February 1992. This site is located on the west or leeward coast near the southern end of Prince Rupert Bay. This is an important tourist beach. The beach consists of sand. Table 14 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 30. This shows the expected seasonal changes for a west coast beach with erosion during the winter months of November and March and accretion during the summer months particularly during August. The erosion is associated with high swells emanating from intense North Atlantic storms during the winter months. Seasonal changes for the years 1989 to 1992 are not so obvious partly because of the infrequency of measurement in some years and partly because of severe erosion and subsequent recovery after Hurricanes Gabrielle and Hugo in 1989.

Annual Changes

Figure 31 shows a bar graph illustrating the annual changes at this site. The mean values for 1987 and 1988 were fairly consistent, there was some erosion in the first half of 1989. But then following Hurricane Hugo in September 1989 there was very significant erosion such that the profile area decreased by -57%. However, since 1990 the beach has recovered, but not to the pre-hurricane levels.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -12% and the profile width decreased by 3.430 m or -12%. This represents an erosion rate of -0.7 m per year.

TABLE 14 DATA RECORD - COCONUT BEACH
AUGUST 1987 TO FEBRUARY 1992

Date	Profile Area (sq.m)	Profile Width (m)
14.08.87	28.110	25.733
02.12.87	29.600	30.702
14.03.88	24.432	28.298
10.05.88	27.206	30.805
11.08.88	37.699	36.072
01.12.88	23.815	27.801
21.03.89	25.973	28.759
07.06.89	23.508	26.463
10.08.89	26.200	28.026
----------Hurricane Gabrielle----------		
14.09.89	18.187	23.108
----------Hurricane Hugo----------		
27.09.89	8.935	10.210
20.10.89	9.599	11.222
29.11.89	11.619	13.464
05.01.90	17.332	19.267
22.02.90	16.550	17.760
09.05.90	22.165	21.819
12.09.90	21.172	20.513
13.02.91	21.574	19.969
04.09.91	21.042	20.905
29.11.91	24.701	20.927
25.02.92	25.486	24.788

DATA SUMMARY - COCONUT BEACH - 1987 - 1992

Year	Mean Profile Area (sq.m)	% Change in profile area	Mean Profile Width (m)
1987	28.855		28.218
1988	28.288	- 2	30.744
1989pre H.Hugo	23.467	- 17	26.589
1989postH.Hugo	10.051	- 57	11.632
1990	19.305	+ 92	19.840
1991	22.439	+ 16	20.600
1992	25.486	+ 14	24.788

FIGURE 30

Coconut Beach
Seasonal Changes 1988

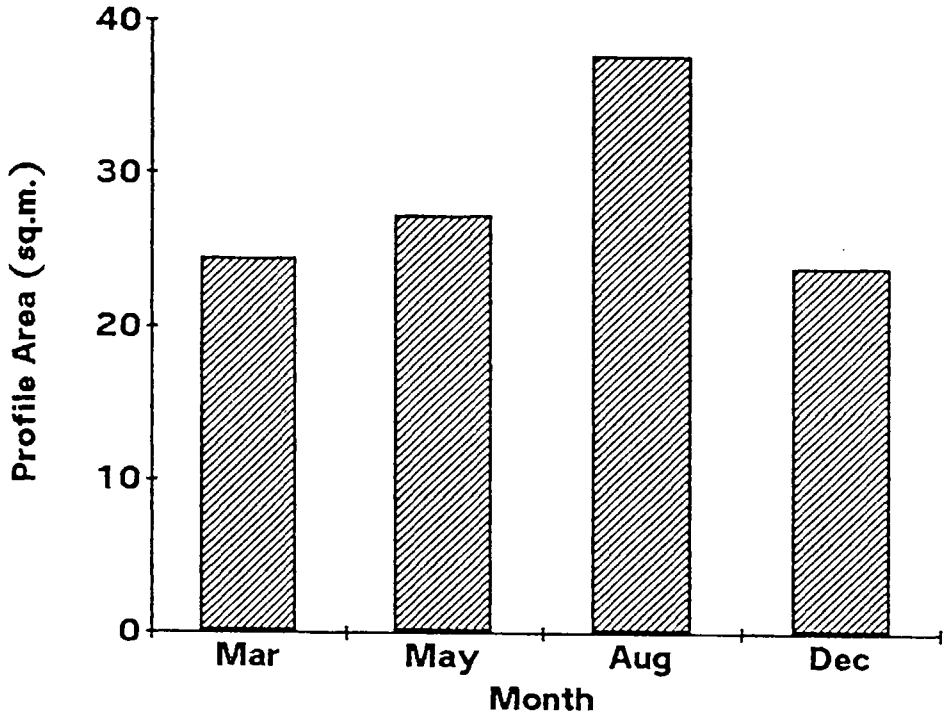
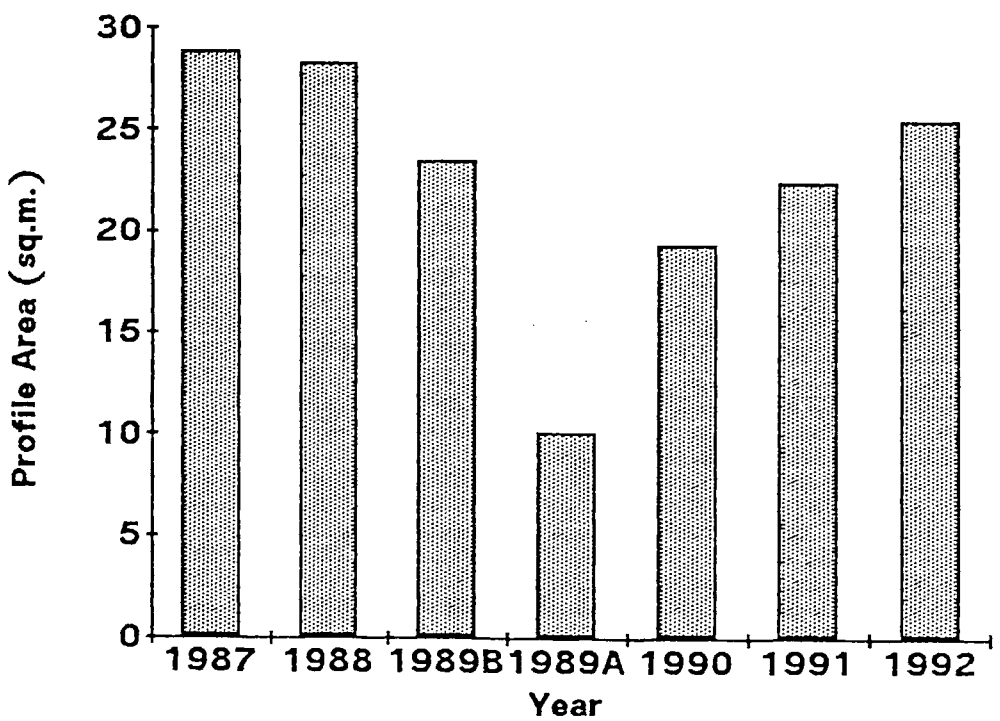


FIGURE 31

Coconut Beach
Annual Changes 1987-1992



PURPLE TURTLE BEACH – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in February 1992. This site is located on the west or leeward coast near the northern end of Prince Rupert Bay. This is an important recreational beach. The beach consists of sand. Table 15 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 32. This shows the expected seasonal changes for a west coast beach with erosion during the winter months around November and accretion during the summer months particularly during August. The erosion is associated with high swells emanating from intense North Atlantic storms during the winter months. Seasonal changes for the years 1989 to 1992 are not so obvious partly because of the infrequency of measurement in some years and partly because of severe erosion and subsequent recovery after Hurricanes Gabrielle and Hugo in 1989.

Annual Changes

Figure 33 shows a bar graph illustrating the annual changes at this site. The mean values for 1987, 1988 and the first half of 1989 showed slight but steady erosion. There was dramatic erosion after Hurricane Hugo in September, 1989. The beach profile showed some recovery over the period 1990-1992, however, it is significant that the profile never returned to its pre-hurricane level.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -19% and the profile width decreased by 4.872 m or -16%. This represents an erosion rate of -1.0 m per year.

It should also be noted that this profile was showing erosion prior to the hurricanes of 1989.

TABLE 15 DATA RECORD - PURPLE TURTLE BEACH
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (Sq.m.)	Profile Width (m)
18.08.87	35.930	30.852
02.12.87	39.070	31.929
14.03.88	35.739	30.231
18.05.88	33.800	30.244
11.08.88	37.707	31.409
01.12.88	30.495	27.120
21.05.89	35.058	30.298
07.06.89	32.060	29.079
10.08.89	33.000	30.308
- - - - Hurricane Gabrielle - - - -		
14.09.89	32.756	29.334
- - - - Hurricane Hugo - - - -		
27.09.89	22.091	21.750
20.10.89	21.240	20.821
29.11.89	20.060	20.800
05.01.90	26.895	24.668
22.02.90	27.163	24.224
09.05.90	26.671	24.734
12.09.90	25.464	23.590
04.09.91	28.322	25.605
19.11.91	32.253	27.127
25.02.92	30.399	26.519

DATA SUMMARY - PURPLE TURTLE BEACH - 1987 TO 1992

Year	Mean Profile Area (sq.m.)	%Change in profile area	Mean Profile Width (m.)
1987	37.500		31.391
1988	34.435	- 8	29.751
1989 pre H.Hugo	33.218	- 4	29.755
1989post H. Hugo	21.130	-36	21.124
1990	26.548	+26	24.304
1991	30.293	+14	26.366
1992	30.399	0	26.519

FIGURE 32

Purple Turtle Beach
Seasonal Changes 1988

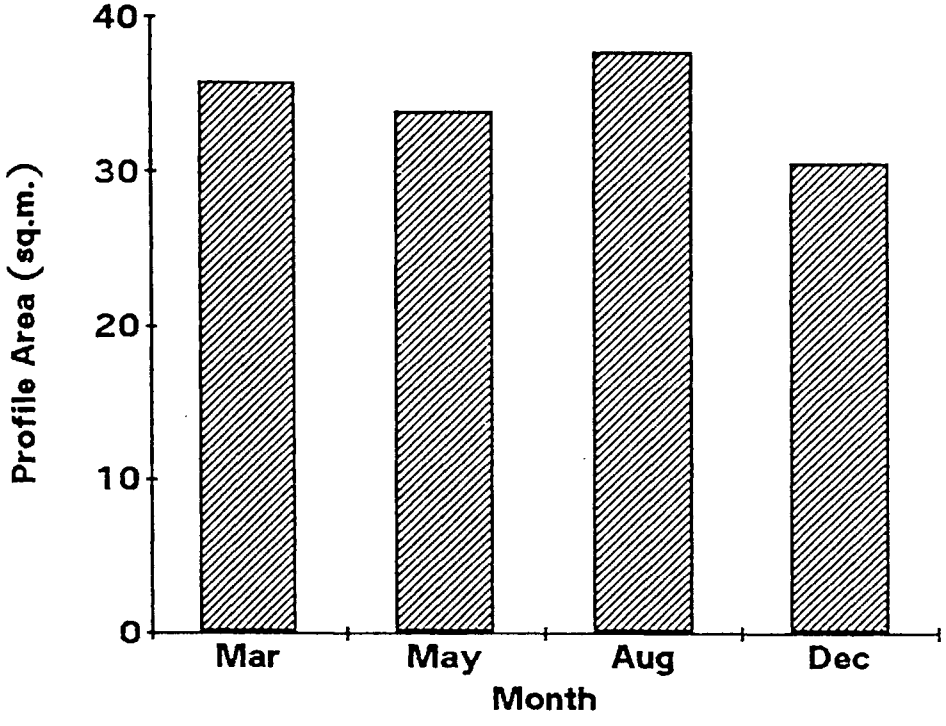
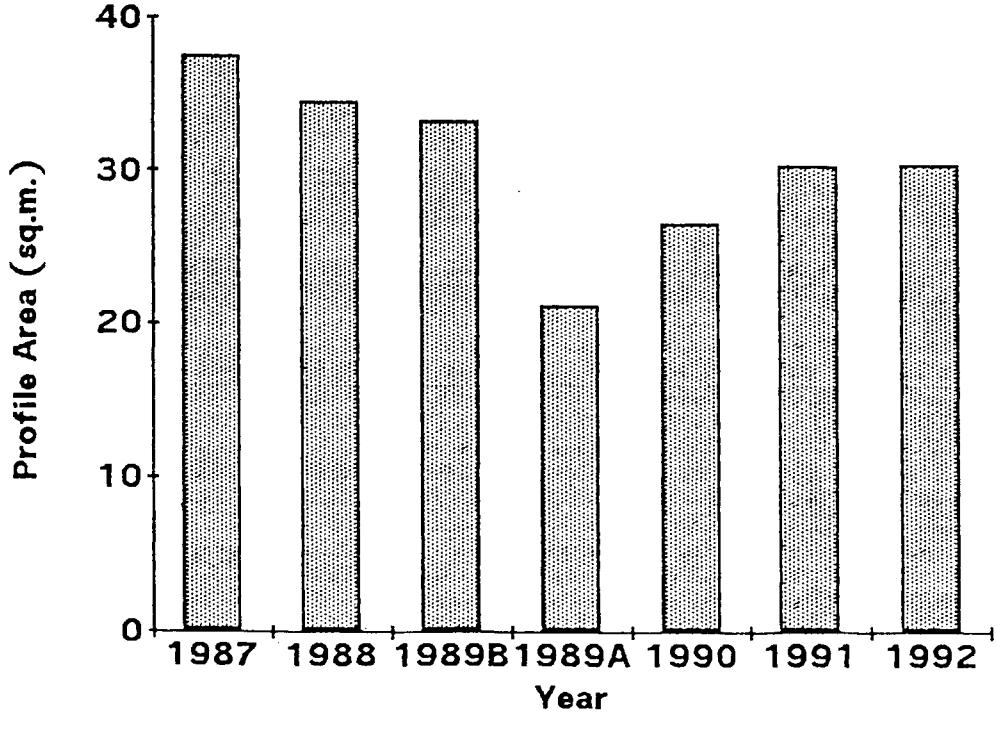


FIGURE 33

Purple Turtle Beach
Annual Changes 1987-1992



BELLE HALL BEACH – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987 and the last measurement recorded was in February 1992. The site is located on the west coast of Dominica. The beach is exposed to low wave energy for most of the year. The beach consists of sand. Table 16 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes for 1988 is shown in Figure 34. This does not show the expected seasonal pattern for a west coast beach with erosion during the winter months of December to March, and accretion during the summer months of May through August. In actual fact the lowest value recorded in 1988 was during the summer, August, for the other months the values showed little variation. Seasonal changes for the years after 1988 did not show any seasonal pattern, mainly because of the 1989 hurricanes and subsequent beach recovery.

Annual Changes

Figure 35 shows a bar graph illustrating the annual changes at this site. Before the 1989 hurricanes the mean profile areas were very uniform. However, after Hurricane Hugo there was very significant erosion and the sand beach was replaced with sand and stones. After the hurricane the beach recovered, but not to its pre-hurricane level.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -13% and the profile width decreased by 5.098 m or -17%. This represents an erosion rate of -1.0 m per year.

TABLE 16 DATA RECORD - BELLE HALL
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq.m.)	Profile Width (m.)
14.08.87	49.637	28.742
02.12.87	52.467	31.408
14.03.88	53.224	32.834
18.05.88	54.986	33.590
11.08.88	42.377	29.027
01.12.88	51.943	30.546
21.03.89	49.189	27.987
07.06.89	51.846	27.603
10.08.89	52.344	27.285
----------Hurricane Gabrielle----------		
14.09.89	49.588	27.111
----------Hurricane Hugo----------		
27.09.89	36.326	18.991
20.10.89	35.253	18.021
29.11.89	42.934	25.047
05.01.90	41.800	22.411
22.02.90	40.454	21.941
09.05.90	41.346	22.068
15.08.90	41.540	21.677
18.02.91	40.156	19.937
04.02.91	41.069	22.070
29.11.91	39.129	21.744
25.02.92	44.516	24.977

DATA SUMMARY BELLE HALL - 1987 - 1992

Year	Mean Profile Area (sq.m.)	& Change in Profile Area	Mean Profile Width (m.)
1987	51.052		30.075
1988	50.633	- 1	31.499
1989preHH	50.742	0	27.497
1989postHH	38.171	-25	20.686
1990	41.285	+ 8	22.024
1991	40.118	- 3	21.250
1992	44.516	+11	24.977

FIGURE 34

Belle Hall
Seasonal Changes 1988

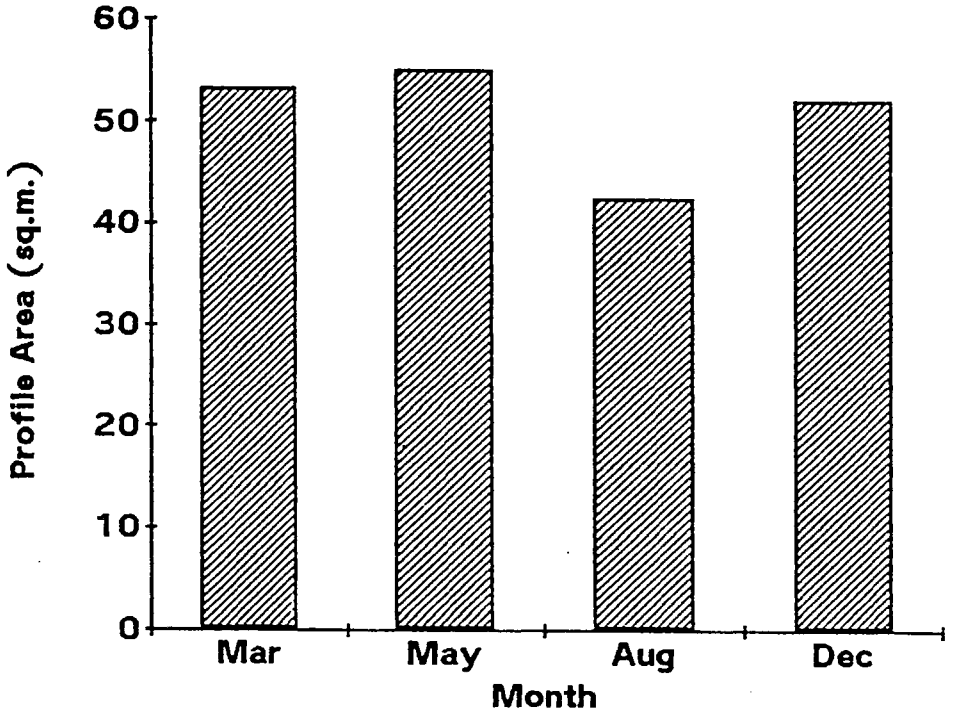
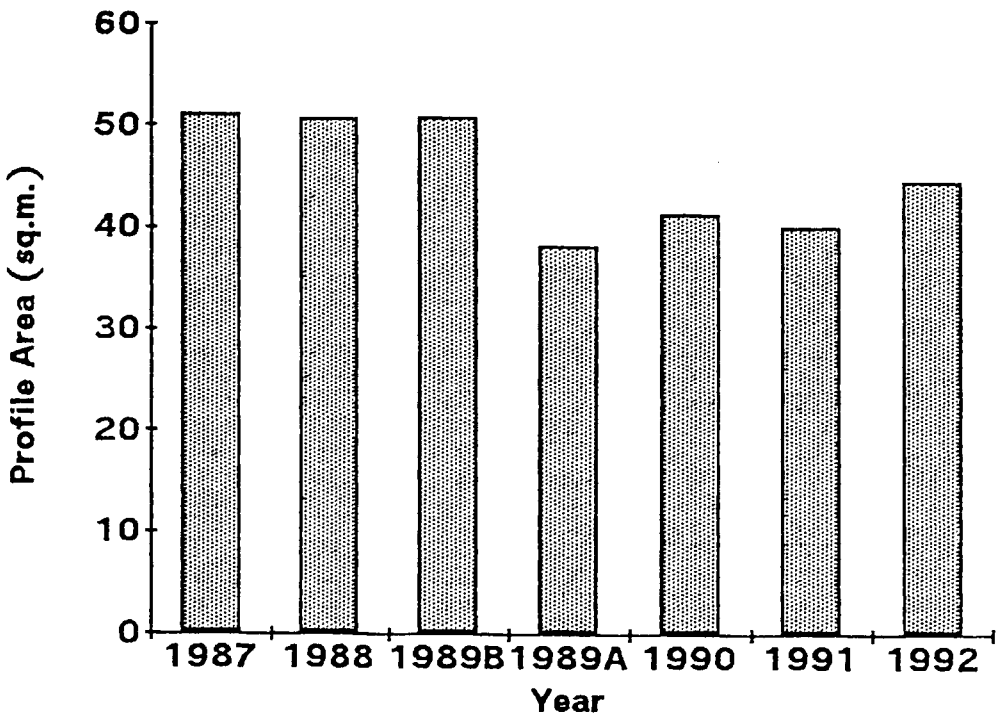


FIGURE 35

Belle Hall
Annual Changes 1987-1992



TOUCARIE BAY – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in February 1992. This site is located on the west or leeward coast near the northern end of the island. The beach has suffered from sand mining and the road has had to be protected with gabions. The beach consists of sand. Table 17 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 36. This shows the expected seasonal changes for a west coast beach with erosion during the winter months of November and March and accretion during the summer months of May and August. The erosion is associated with high swells emanating from intense North Atlantic storms during the winter months. Seasonal changes for the years 1989 to 1992 are not so obvious partly because of the infrequency of measurement in some years and partly because of severe erosion and subsequent recovery after Hurricanes Gabrielle and Hugo in 1989.

Annual Changes

Figure 37 shows a bar graph illustrating the annual changes at this site. The mean values for 1987, 1988 and the first half of 1989 showed some fluctuation but no clear pattern. There was dramatic erosion after Hurricane Hugo in September, 1989, and as a result gabions were installed at the back of the beach in December 1989. The beach profile showed some recovery over the period 1990-1992, however, it is significant that the profile never returned to its pre-hurricane level.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -21% and the profile width decreased by 3.628 m or -13%. This represents an erosion rate of -0.7 m per year.

TABLE 17 DATA RECORD - TOUCARIE BAY
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq.m)	Profile Width (m)
14.08.87	47.529	27.362
02.12.87	49.388	28.620
14.03.88	33.509	20.237
18.05.88	47.261	28.054
11.08.88	43.493	27.061
01.12.88	38.247	24.752
21.03.89	45.449	25.435
07.06.89	48.161	26.890
10.08.89	42.917	26.167
----------	Hurricane Gabrielle	----------
14.09.89	43.617	25.875
----------	Hurricane Hugo	----------
27.09.89	27.437	16.484
20.10.89	28.798	17.091
29.11.89	31.462	18.872
05.01.90	34.796	19.508
22.02.90	34.918	20.328
09.05.90	32.037	18.165
15.08.90	37.134	21.504
13.02.91	35.413	19.858
04.09.91	27.760	15.006
29.11.91	33.042	20.314
25.02.92	38.244	24.163

DATA SUMMARY - TOUCARIE BAY - 1987 TO 1992

Year	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m.)
1987	48.459		27.791
1988	40.628	- 16	25.026
1989 pre H.Hugo	45.036	+ 11	26.092
1989post H.Hugo	29.224	- 35	17.482
1990	34.721	+ 19	19.876
1991	32.072	- 8	18.393
1992	38.244	+ 19	24.163

FIGURE 36

Toucarie Bay
Seasonal Changes 1988

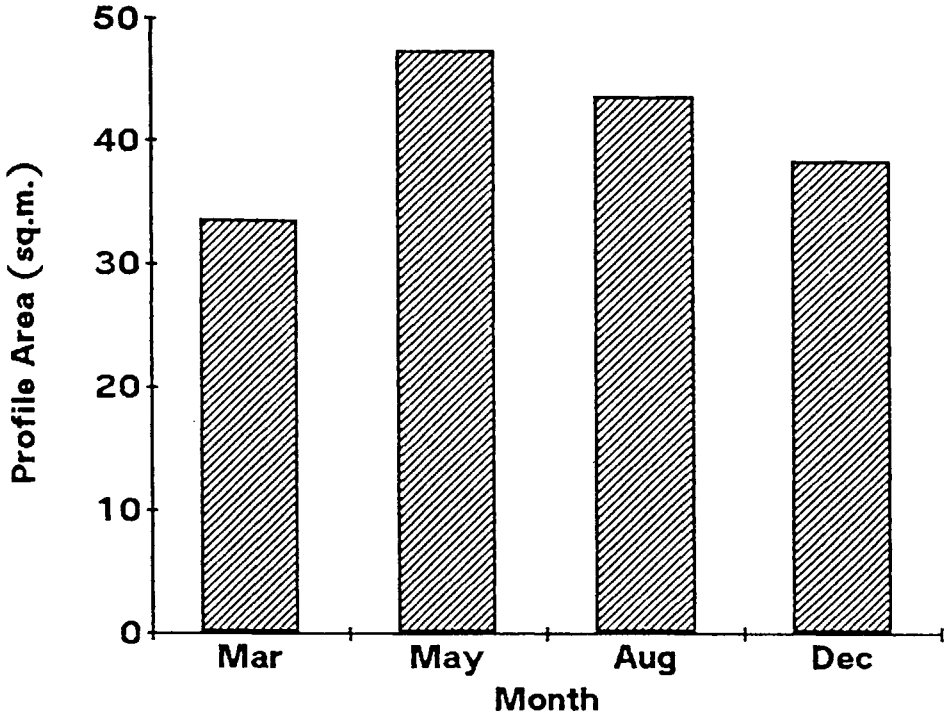
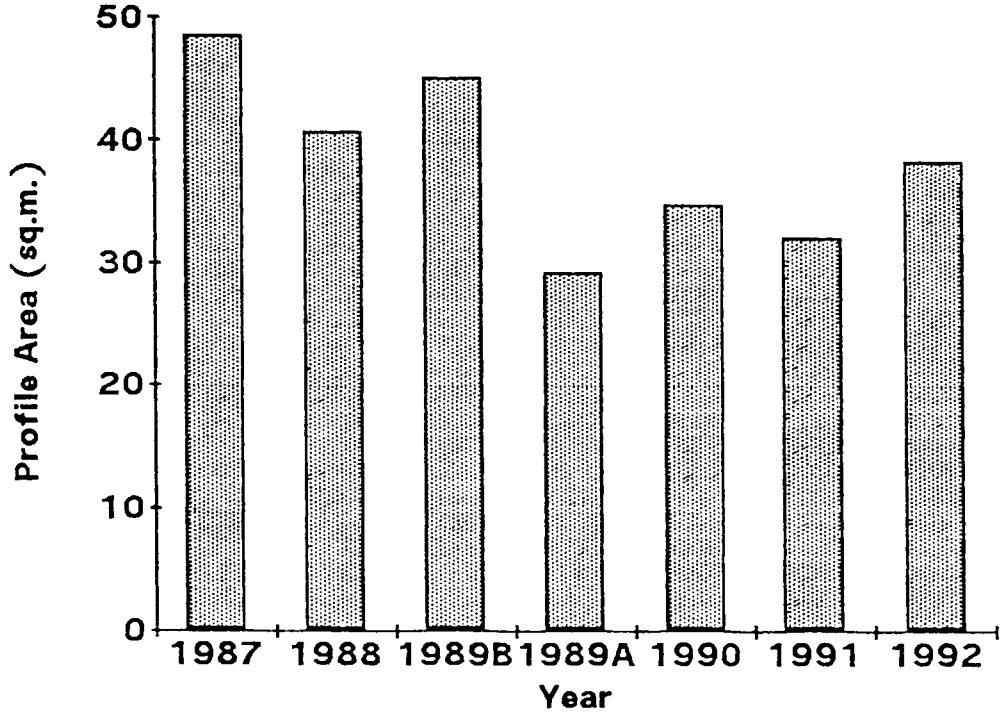


FIGURE 37

Toucarie Bay
Annual Changes 1987-1992



HAMPSTEAD BEACH – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in February 1992. This site is located on the northeastern coast of Dominica. The beach is in a fairly sheltered bay protected by reefs. The beach consists of sand. Table 18 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 38. This shows the expected seasonal changes for a north coast beach with erosion during the winter months of November and March and accretion during the summer months of May and August. North coast beaches also experience winter swells originating from intense North Atlantic storms, but in addition they usually experience high wave energy in the winter months from waves generated by the northeasterly Trade Winds. Seasonal changes for the years 1989 to 1992 are not so obvious partly because of the infrequency of measurement in some years and partly because of erosion and subsequent recovery after Hurricanes Gabrielle and Hugo in 1989.

Annual Changes

Figure 39 shows a bar graph illustrating the annual changes at this site. The mean values for 1987, 1988 and the first half of 1989 showed slight accretion. The north coast and east coast beaches experienced swells from Hurricane Gabrielle in early September 1989. Hurricane Hugo had little further impact. In addition, with Hurricane Hugo the most damaging waves approached from the west generated by the southern portion of the hurricane. This site experienced only slight erosion from Hurricane Gabrielle, presumably the reefs provided some protection. This profile site may not be representative of the entire beach, observations showed more erosion to the east of the profile line after Hurricane Gabrielle. In addition the east facing beaches suffered the most serious effects from Hurricane Gabrielle, and this site is a north facing beach. During 1990 to 1992 the beach totally recovered from the effects of Hurricane Gabrielle.

A comparison of the 1987 data with the 1992 data shows that the profile area increased by +9% and the profile width decreased by 2.507 m or -8%. This represents an erosion rate of -0.5 m per year. (The fact that the area increased and the width decreased would indicate a steepening of the profile which is usually indicative of erosion).

TABLE 18 DATA RECORD - HAMPSTEAD
AUGUST 1987 TO FEBRUARY 1992

Date	Profile Area (sq.m)	Profile Width (m)
17.08.87	35.850	35.875
08.12.87	27.499	24.216
13.03.88	31.054	27.039
19.05.88	38.210	35.909
22.08.88	41.658	33.732
02.12.88	31.607	27.191
22.03.89	36.687	28.845
25.05.89	39.829	37.745
18.08.89	30.548	27.629
----------Hurricane Gabrielle----------		
12.09.89	28.916	26.878
----------Hurricane Hugo----------		
30.09.89	31.147	33.935
23.11.89	31.972	31.250
15.02.90	31.234	29.079
16.05.90	33.651	33.410
21.08.90	35.953	34.709
21.11.90	37.726	35.253
21.08.91	34.579	32.352
19.11.91	40.029	36.577
26.02.92	34.613	27.539

DATA SUMMARY - HAMPSTEAD - 1987 - 1992

Year	Mean Profile Area (sq.m)	% Change in Profile Area	Mean Profile Width (m)
1987	31.675		30.046
1988	35.632	- 12	30.968
1989pre H.Gab	35.688	0	31.406
1989postH.Gab	30.678	- 14	30.687
1990	34.641	+ 13	33.113
1991	37.304	+ 8	34.465
1992	34.613	- 7	27.539

FIGURE 38

Hampstead

Seasonal Changes 1988

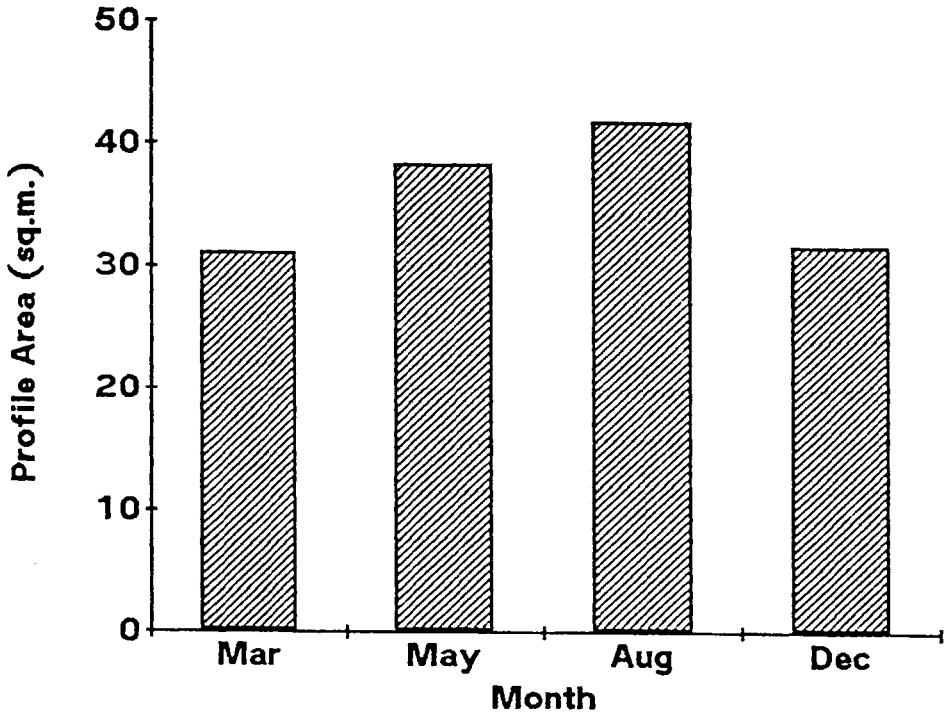
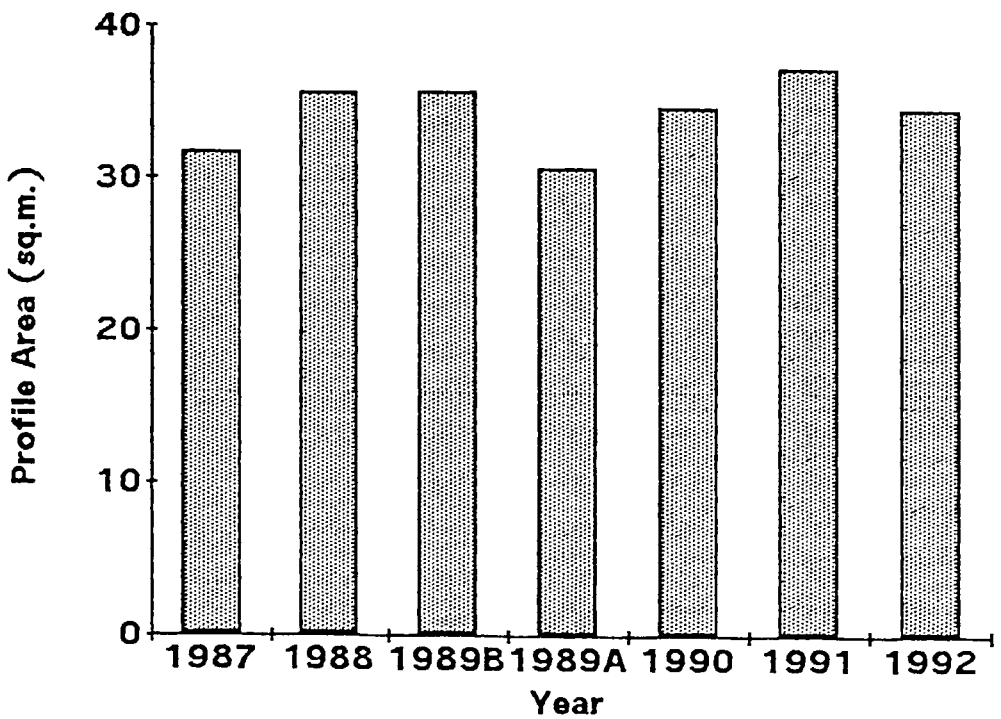


FIGURE 39

Hampstead

Annual Changes 1987-1992



POINTE BAPTISTE BEACH – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in February 1992. This site is located on the northeastern coast of Dominica. The beach is in a fairly sheltered bay protected by reefs. The beach consists of sand. Table 19 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 40. This does not show the expected seasonal changes for a north coast beach with erosion during the winter months of November and March and accretion during the summer months of May and August. The reason for this is unknown at present. The years 1989 to 1992 did not show any clear pattern of seasonal changes.

Annual Changes

Figure 41 shows a bar graph illustrating the annual changes at this site. The mean values for 1987, 1988 and the first half of 1989 showed slight accretion. The north coast and east coast beaches experienced swells from Hurricane Gabrielle in early September 1989, and as a result Hurricane Hugo had little further impact. In addition with Hurricane Hugo the most damaging waves approached from the west generated by the southern portion of the hurricane. This site experience some erosion from Hurricane Gabrielle. During 1990 to 1992 the beach totally recovered from the effects of Hurricane Gabrielle.

A comparison of the 1987 data with the 1992 data shows that the profile area increased by +5% and the profile width decreased by 1.705 m or -7%. This represents an erosion rate of 0.34 m per year. Thus while the profile area increased, the width decreased, indicating the profile was becoming steeper, which is generally a sign of erosion.

TABLE 19 DATA RECORD - POINTE BAPTISTE, CALIBISHIE
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq m)	Profile Width (m)
17.08.87	44.048	23.760
08.12.87	43.924	24.010
18.03.88	50.180	27.673
19.05.88	55.654	30.041
24.08.88	46.757	25.277
02.12.88	43.654	22.366
22.03.89	46.935	24.419
25.05.89	51.112	28.128
18.08.89	41.237	22.468
----------Hurricane Gabrielle----------		
12.09.89	36.019	19.229
----------Hurricane Hugo----------		
30.09.89	36.584	23.487
20.10.89	37.340	21.350
23.11.89	42.262	22.406
15.02.90	37.381	18.205
16.05.90	45.945	23.983
21.08.90	43.770	24.834
21.11.90	44.460	23.677
21.08.91	48.425	26.429
19.11.91	46.957	24.184
26.02.92	46.192	22.180

DATA SUMMARY - POINTE BAPTISTE, CALIBISHIE - 1987 TO 1992

Year	Mean Profile Area (sq.m)	% Change in profile area	Mean Profile Width (m)
1987	43.986		23.885
1988	49.061	+ 11	26.339
1989pre H. Gab	46.428	+ 5	25.005
1989post H.Gab	38.051	- 18	21.618
1990	42.889	+ 13	22.675
1991	47.691	+ 11	25.307
1992	46.192	- 3	22.180

FIGURE 40

Pointe Baptiste Calibishie
Seasonal Changes 1988

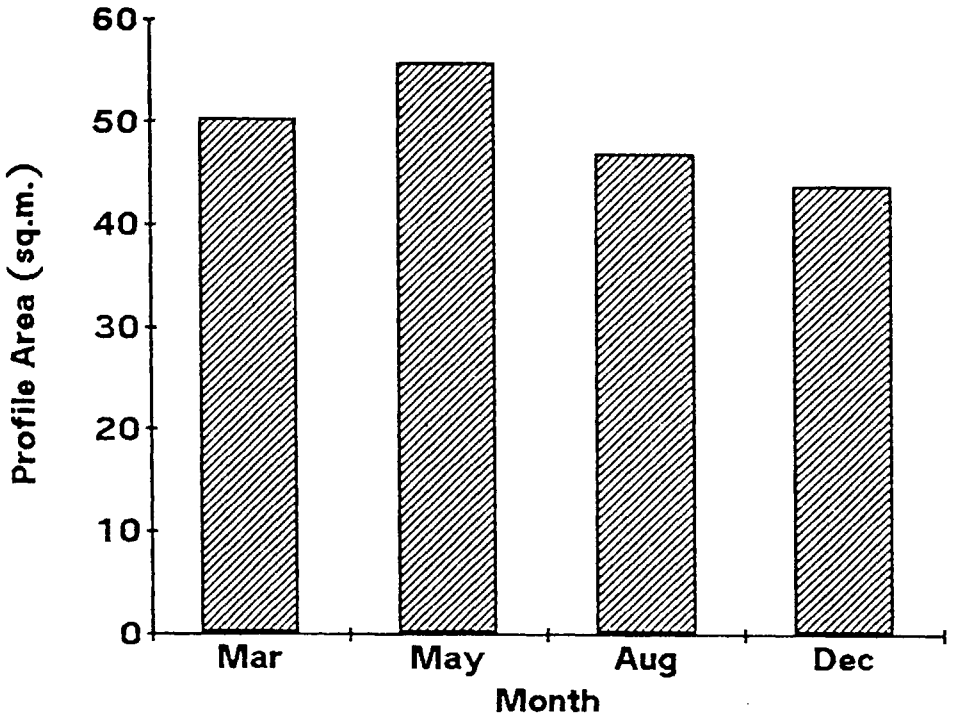
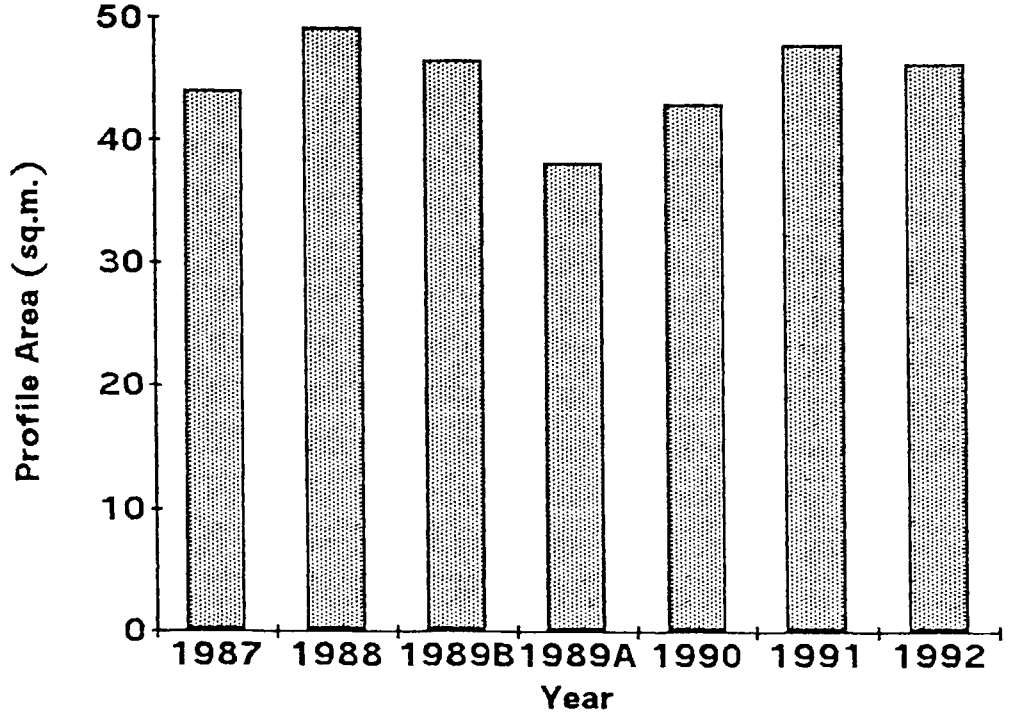


FIGURE 41

Pointe Baptiste Calibishie
Annual Changes 1987-1992



WOODFORD HILL – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in February 1992. This site is located on the northeastern coast of Dominica. The beach consists of sand, and is a fairly exposed beach with moderate to high wave energy. Table 20 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 42. This shows the expected seasonal changes for a north coast beach with erosion during the winter months of November and March and accretion during the summer months of May and August. North coast beaches also experience winter swells originating from intense North Atlantic storms, but in addition they usually experience high wave energy in the winter months from waves generated by the Northeasterly Trade Winds. Seasonal changes for the years 1989 to 1992 are not so obvious partly because of the infrequency of measurement in some years and partly because of erosion and subsequent recovery after Hurricanes Gabrielle and Hugo in 1989.

Annual Changes

Figure 43 shows a bar graph illustrating the annual changes at this site. A very high value was recorded in 1987, but the beach was reduced to almost half that value in 1988, this was due to some severe northerly swells at the beginning of 1988. After Hurricane Gabrielle the beach accreted significantly. So at this site the swells from Hurricane Gabrielle bought sand in from the offshore zone, rather than eroding sand from the beach. In 1990 there was significant erosion followed by accretion in 1991 and 1992. This is a very dynamic beach site, which shows dramatic changes from season to season and year to year. However, there does not seem to be any clear trend over the six-year measurement period.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -21% and the profile width decreased by -0.647 m or -2%. This represents an erosion rate of -0.1 m per year. (The erosion rate which is based on width measurements only does not give a true picture of the changes at this site).

TABLE 20 DATA RECORD - WOODFORD HILL
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq.m.)	Profile Width (m)
17.08.87	94.484	37.476
08.12.87	98.378	37.307
18.03.88	39.078	32.484
19.05.88	62.363	40.050
24.08.88	75.438	49.927
02.12.88	39.321	25.435
22.03.89	38.196	26.072
25.05.89	50.756	34.668
18.08.89	72.362	37.103
----------Hurricane Gabrielle----------		
12.09.89	86.252	35.495
----------Hurricane Hugo----------		
30.09.89	80.747	36.269
23.11.89	81.209	34.273
15.02.90	36.311	24.015
16.05.90	40.437	29.572
21.08.90	49.697	31.067
21.11.90	64.957	33.732
21.08.91	71.102	36.233
19.11.91	79.340	35.372
26.02.92	76.043	36.745

DATA SUMMARY - WOODFORD HILL - 1987 TO 1992

Year	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m)
1987	96.430		37.392
1988	54.050	- 44	28.502
1989pre H.Gab	53.771	- 1	32.614
1989postH.Gab	82.736	+ 54	35.346
1990	47.851	- 42	29.600
1991	75.221	+ 57	35.803
1992	76.043	+ 1	36.745

FIGURE 42

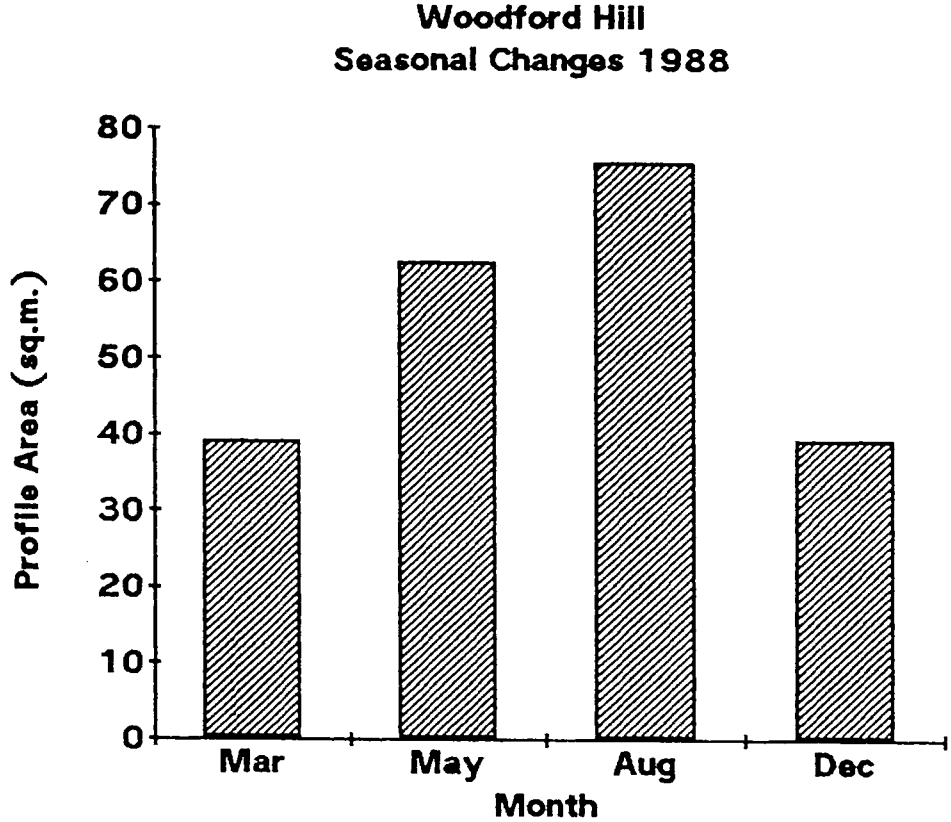
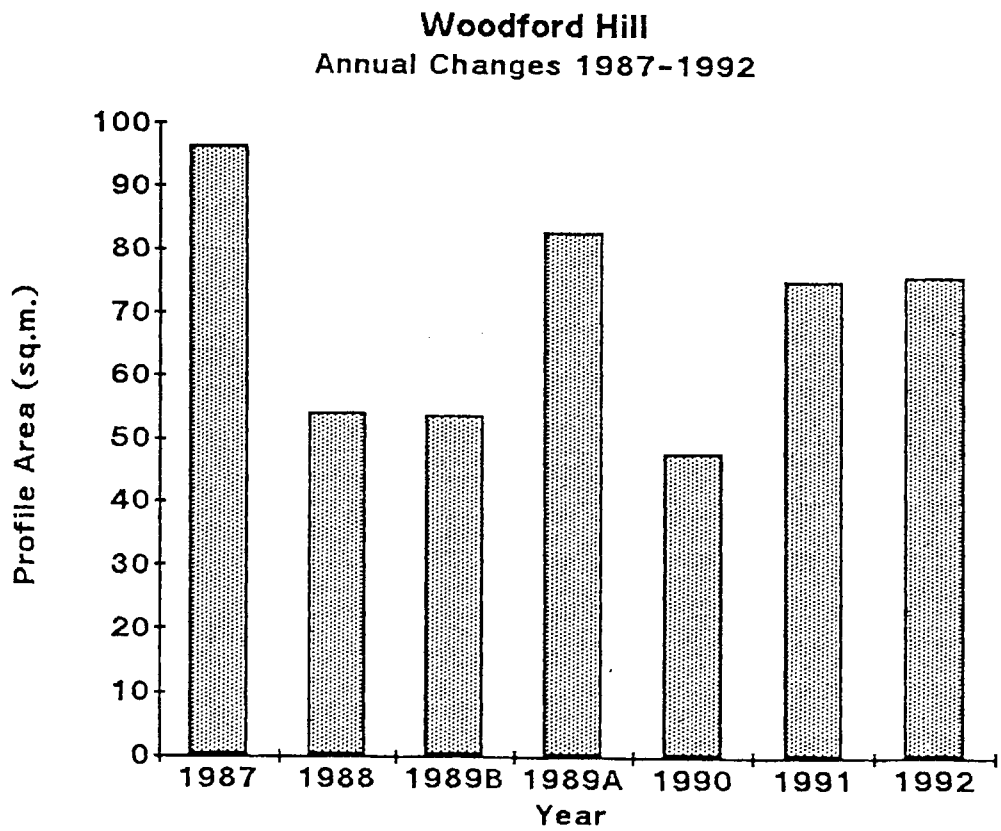


FIGURE 43



LONDONDERRY - BEACH CHANGES 1987 TO 1992

This profile was started in August 1987 and the last measurement recorded was in February 1992. The site is located on the eastern coast of Dominica. The beach is exposed to high wave energy for most of the year. The beach usually consists of sand. Table 21 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes for 1988 is shown in Figure 44. This shows the expected seasonal pattern for an east coast beach with erosion during the winter months of December to March, and accretion during the summer months of May through August. This is mainly due to the Trade Winds which blow with considerable strength and constancy from December through April, after which the speed decreases and the direction also varies somewhat. Seasonal changes for the years after 1988 did not show as clear a pattern, mainly because of the 1989 hurricanes and subsequent beach recovery.

Annual Changes

Figure 45 shows a bar graph illustrating the annual changes at this site. Like most other east coast beaches, Londonderry suffered the most severe erosion from Hurricane Gabrielle, after which Hurricane Hugo had little further effect. Following the hurricanes in 1989 the beach recovered, however not to its pre-hurricane condition.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -18% and the profile width decreased by 18.964 m or -32%. This represents an erosion rate of -3.8 m per year.

TABLE 21 DATA RECORD - LONDONDERRY
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq.m.)	Profile Width (m.)
17.08.87	110.741	62.434
08.12.87	113.404	55.333
18.03.88	108.914	47.720
18.05.88	132.077	68.835
24.08.88	147.840	77.527
02.12.88	106.383	50.003
22.03.89	100.631	43.318
25.05.89	109.009	48.657
18.08.89	115.930	57.463
----------Hurricane Gabrielle----------		
12.09.89	83.908	37.254
----------Hurricane Hugo----------		
30.09.89	85.700	37.380
23.11.89	98.524	52.996
13.02.90	97.980	47.619
16.05.90	109.514	67.187
21.08.90	108.769	51.797
21.08.91	103.488	52.445
19.11.91	109.373	61.139
26.02.92	92.411	39.920

DATA SUMMARY LONDONDERRY - 1987 - 1992

Year	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m.)
1987	112.073		58.884
1988	123.054	+10	61.021
1989preHG	108.523	-12	49.813
1989postHG	89.375	-18	42.543
1990	105.421	+18	55.534
1991	106.431	+ 1	56.792
1992	92.411	-13	39.920

FIGURE 44

Londonderry
Seasonal Changes 1988

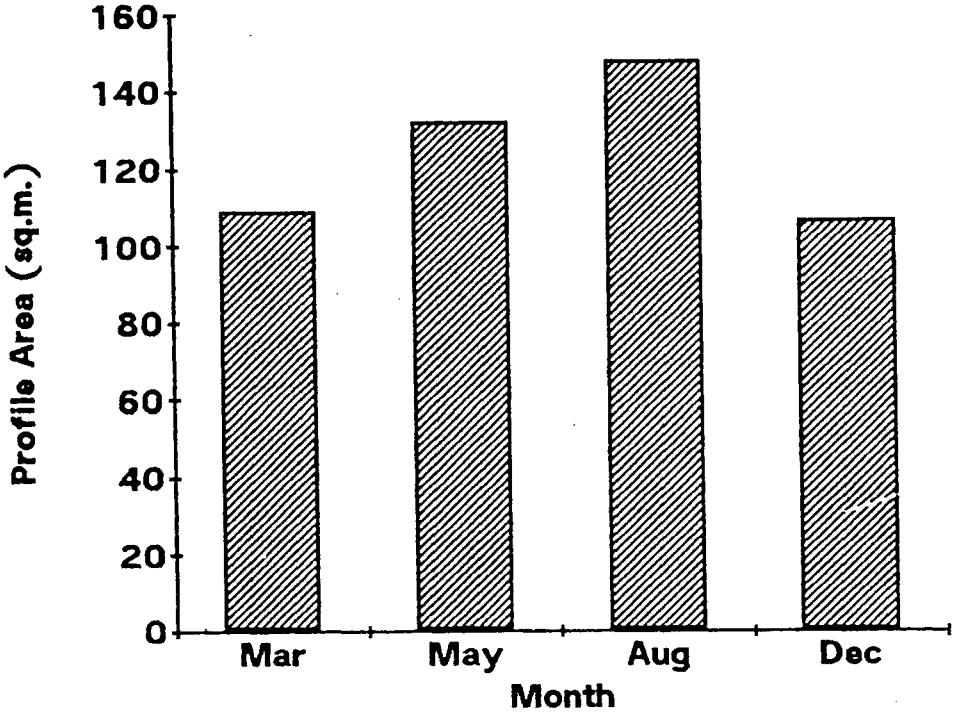
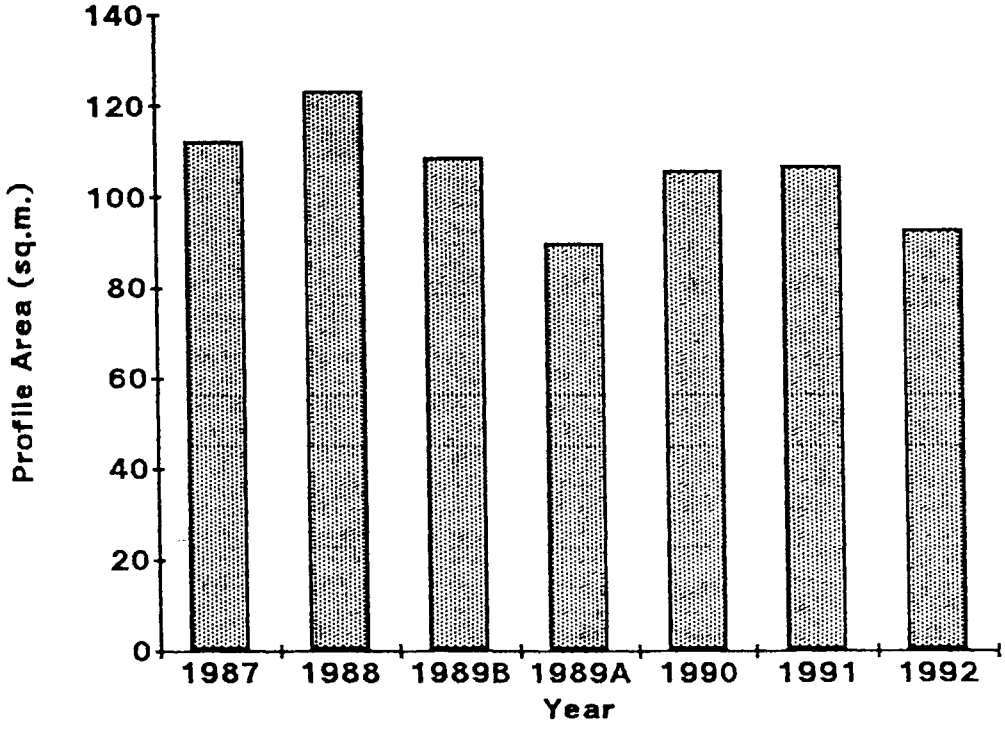


FIGURE 45

Londonderry
Annual Changes 1987-1992



PAGUA BAY – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in February 1992. This site is located on the eastern coast of Dominica. The beach is exposed to high wave energy for most of the year. The beach consists of sand. Table 22 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 46. This shows the expected seasonal changes for an east coast beach with erosion during the winter months of December to March and accretion during the summer months of May and August. (In 1988 there was accretion during November, presumably before the high wave energy from the Trade Winds started). East coast beaches also experience winter swells originating from intense North Atlantic storms, but in addition they usually experience high wave energy in the winter months from waves generated by the Northeasterly Trade Winds.

Annual Changes

Figure 47 shows a bar graph illustrating the annual changes at this site. The mean values for 1987, 1988 and the first half of 1989 showed little fluctuation. The north coast and east coast beaches experienced swells from Hurricane Gabrielle in early September 1989, and Hurricane Hugo had little further impact. In addition with Hurricane Hugo the most damaging waves approached from the west generated by the southern portion of the hurricane. This site experienced significant erosion from Hurricane Gabrielle. This erosion trend continued during the years 1990 to 1992, indicating that Hurricane Gabrielle had had a lasting effect on this beach. This beach has also been used for sand and stone mining. Gabions were constructed at the northern end of this beach after Hurricane Gabrielle.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -52% and the profile width decreased by -25.101 m or -64%. This represents an erosion rate of -5 m per year. This is a very high erosion rate and in view of the narrowness of the beach in 1992 it may soon become necessary to further protect the road.

TABLE 22 DATA RECORD - PAGUA BAY
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq.m.)	Profile Width (m.)
17.08.87	41.120	40.656
08.12.87	37.767	38.035
18.03.88	33.333	27.812
31.05.88	36.785	31.342
18.08.88	40.847	32.815
02.12.88	45.318	41.452
28.03.89	34.634	24.967
25.05.89	34.833	26.937
18.08.89	49.760	41.470
----------Hurricane Gabrielle----------		
12.09.89	25.198	23.065
----------Hurricane Hugo----------		
30.09.89	27.610	22.993
23.11.89	34.605	24.920
13.02.90	28.073	23.194
16.05.90	31.315	25.756
21.08.90	30.598	20.937
24.08.91	24.777	19.013
19.11.91	28.729	27.585
26.02.92	18.776	14.245

DATA SUMMARY - PAGUA BAY - 1987 TO 1992

Year	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m.)
1987	39.444		39.346
1988	39.071	- 1	33.355
1989pre H.Gab	39.742	+ 2	31.125
1989postH.Gab	29.138	-27	23.659
1990	29.995	+ 3	23.296
1991	26.735	-11	23.299
1992	18.776	-30	14.245

FIGURE 46

Pagua Bay
Seasonal Changes 1988

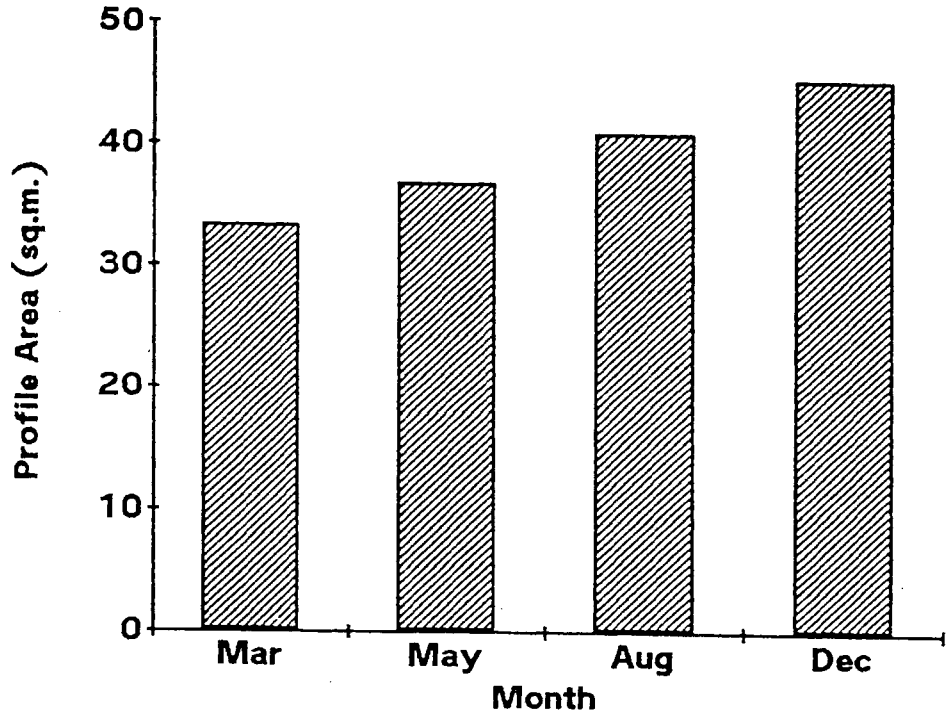
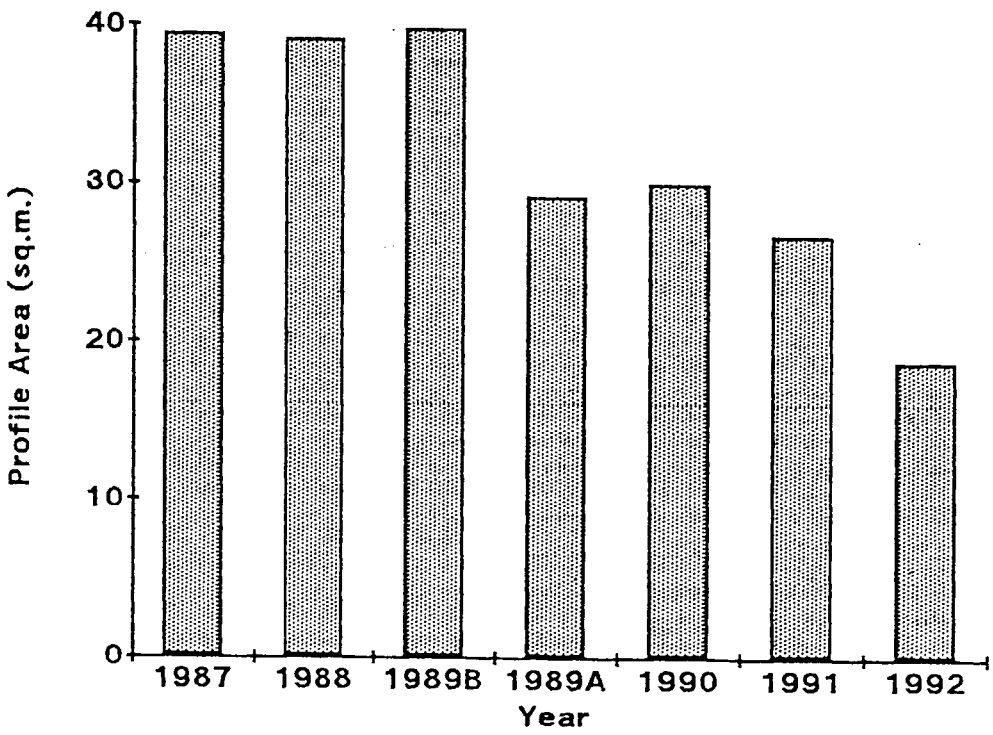


FIGURE 47

Pagua Bay
Annual Changes 1987-1992



CASTLE BRUCE – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987 and the last measurement recorded was in February 1992. The site is located on the eastern coast of Dominica. The beach is exposed to high wave energy for most of the year. The beach consists of sand. Table 23 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes for 1988 is shown in Figure 48. There was no clear pattern at this site as at other east coast sites, the reason for this is unknown. Nor was there any clear pattern after the hurricanes in 1989, but this may partly have been due to the infrequency of measurements in the subsequent years.

Annual Changes

Figure 49 shows a bar graph illustrating the annual changes at this site. Like most other east coast beaches, Castle Bruce suffered the most severe erosion from Hurricane Gabrielle. However, it is interesting to note that in August, 1989, the month before the two hurricanes, there was also significant erosion. This was not observed at other east coast sites and again the reasons are unknown. Following the hurricanes in 1989 the beach recovered to its pre-hurricane condition.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -9% and the profile width decreased by 4.841 m or -10%. This represents an erosion rate of -1.0 m per year.

TABLE 23 DATA RECORD - CASTLE BRUCE
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq.m.)	Profile Width (m.)
18.08.87	80.698	50.088
08.12.87	87.085	48.908
16.03.88	95.864	60.485
31.05.88	79.334	50.649
18.08.88	98.926	48.074
20.12.88	97.371	59.005
28.02.89	83.770	48.145
14.06.89	95.554	53.267
23.08.89	69.647	37.465
----------Hurricane Gabrielle and Hugo----------		
03.10.89	65.608	39.022
30.11.89	70.903	40.948
13.02.90	76.707	45.844
22.08.90	81.153	44.592
03.09.91	81.020	47.679
13.11.91	85.262	58.070
26.02.92	76.239	44.657

DATA SUMMARY CASTLE BRUCE - 1987 - 1992

Year	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m.)
1987	83.892		49.498
1988	92.873	+11	54.553
1989preHG	82.990	-11	46.292
1989postHG	68.256	-18	39.985
1990	86.300	+26	45.218
1991	83.141	- 4	53.874
1992	76.239	- 8	44.657

FIGURE 48

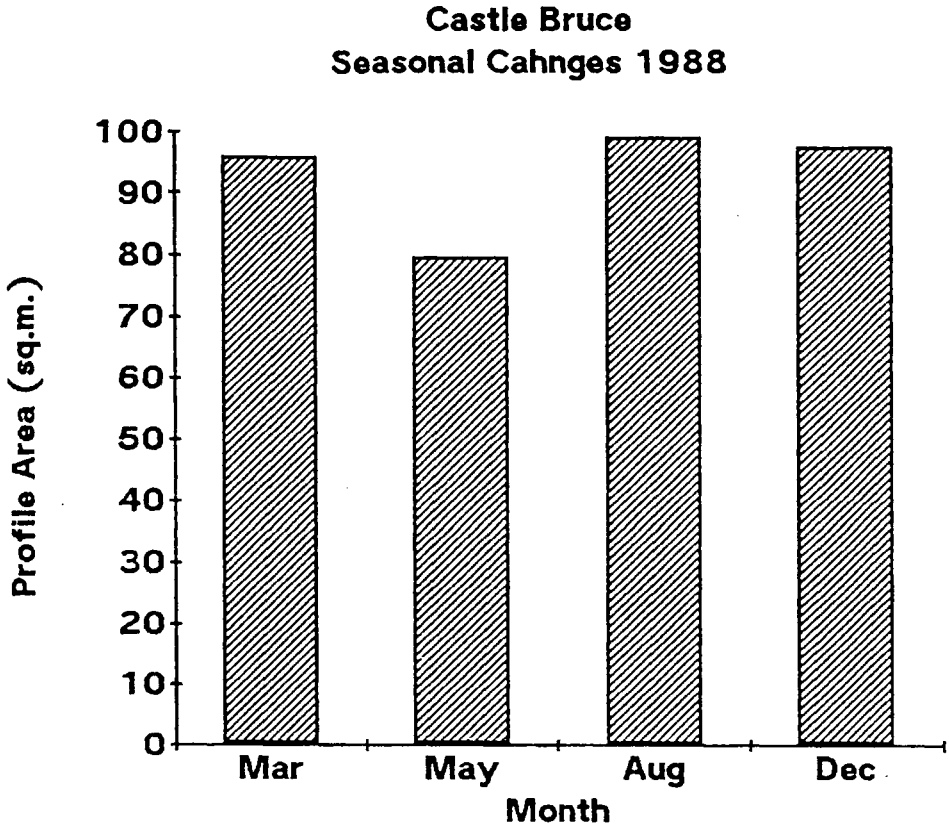
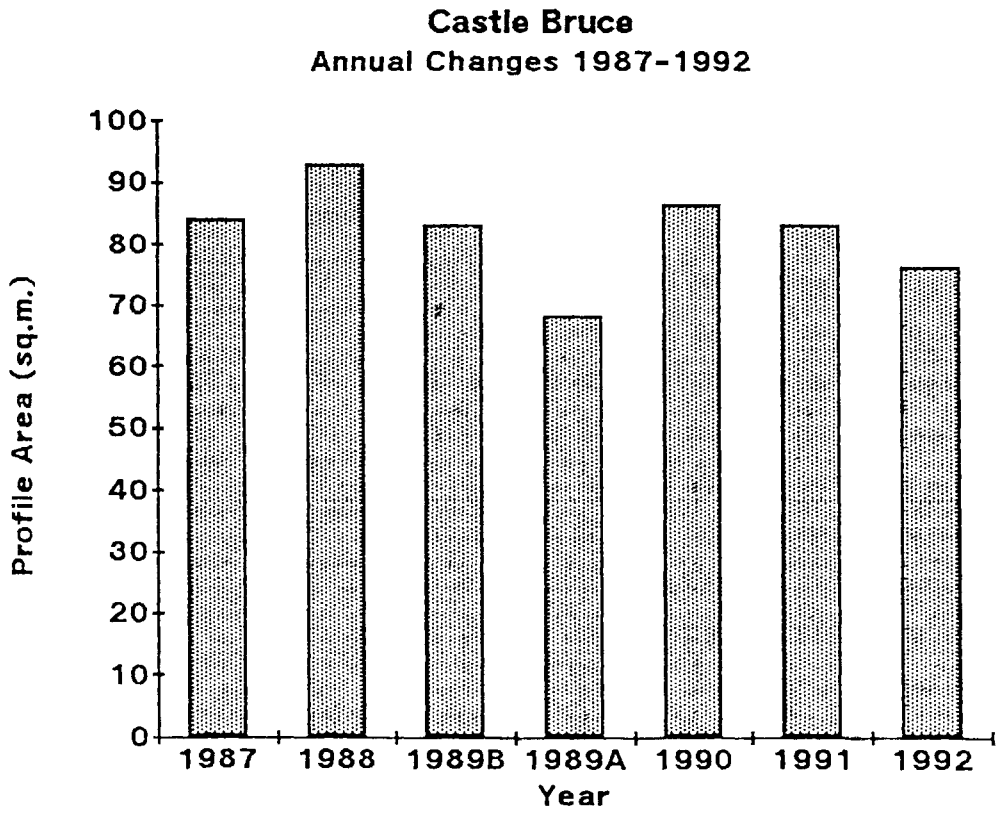


FIGURE 49



BOUT SABLE BEACH (NORTH) – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in February 1992. This site is located on the eastern coast of Dominica. The beach is exposed to high wave energy for most of the year. The beach consists of sand. Table 24 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 50. This does not show a clear seasonal trend for an east coast beach where it would be expected to observe erosion during the winter months of December to March and accretion during the summer months of May and August. While the lowest value recorded was in December the highest value recorded was for March. Thus the seasonal pattern was not clear for 1988 or for subsequent years.

Annual Changes

Figure 51 shows a bar graph illustrating the annual changes at this site. The mean values for 1987, 1988 and the first half of 1989 showed some fluctuation, but the beach was basically stable. The north coast and east coast beaches experienced swells from Hurricane Gabrielle in early September 1989, and Hurricane Hugo had little further impact. However, at this site neither hurricane had any significant impact, the beach showed very slight erosion in October, 1989, but this was slight in comparison to the changes recorded at other sites. The reasons for this are unknown. However, between 1990 and 1992 this site began to show an erosion trend.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -14% and the profile width decreased by -3.763 m or -15%. This represents an erosion rate of -0.8 m per year.

TABLE 24 DATA RECORD - BOUT SABLE NORTH
AUGUST 1987 - FEBRUARY, 1992

Date	Profile Area (sq.m.)	Profile Width (m.)
18.08.87	53.683	26.432
15.12.87	53.896	24.312
16.03.88	65.710	38.122
31.05.88	54.515	27.537
18.08.88	62.669	29.977
20.12.88	53.187	24.178
28.03.89	54.772	24.952
14.06.89	52.356	22.373
23.08.89	54.041	25.496
----------Hurricanes Gabrielle & Hugo----------		
03.10.89	52.169	25.924
30.11.89	58.385	28.197
13.02.90	51.703	22.277
16.05.90	64.747	33.810
22.08.90	54.245	24.674
03.09.91	44.878	20.456
13.11.91	52.994	27.019
26.02.92	46.044	21.609

DATA SUMMARY BOUT SABLE NORTH - 1987 - 1992

Year	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m.)
1987	53.790		25.372
1988	59.020	+10	29.954
1989preHG	53.723	- 9	24.274
1989postHG	55.277	+ 4	27.061
1990	56.898	+ 3	26.920
1991	48.921	-14	23.738
1992	46.044	-6	21.609

FIGURE 50

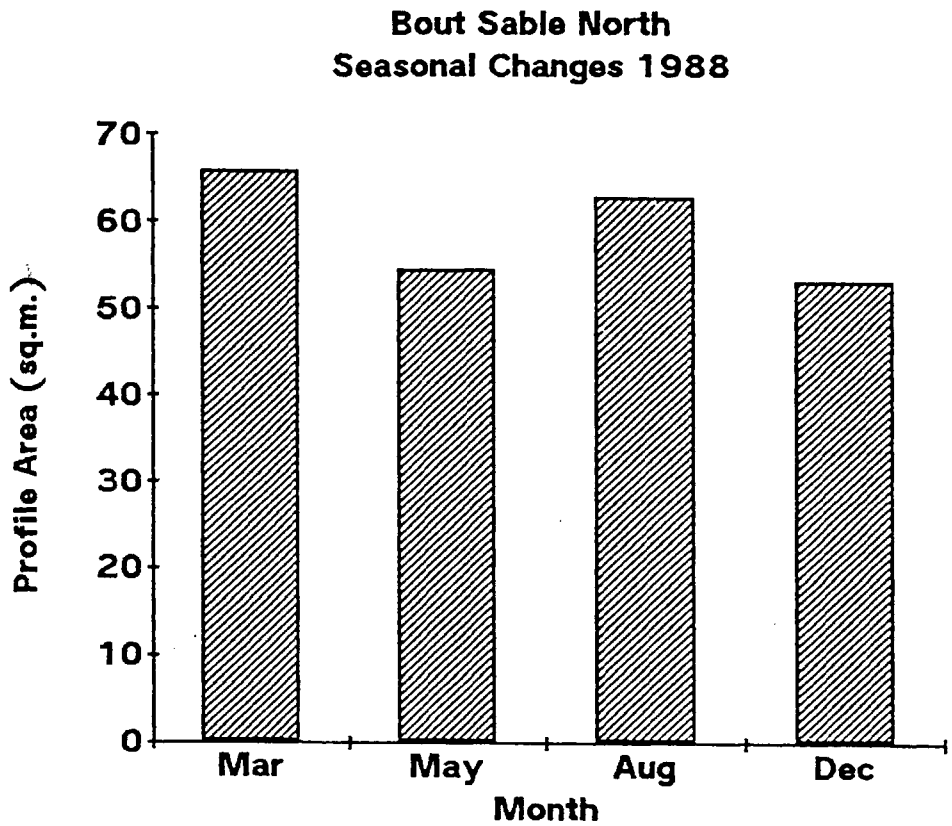
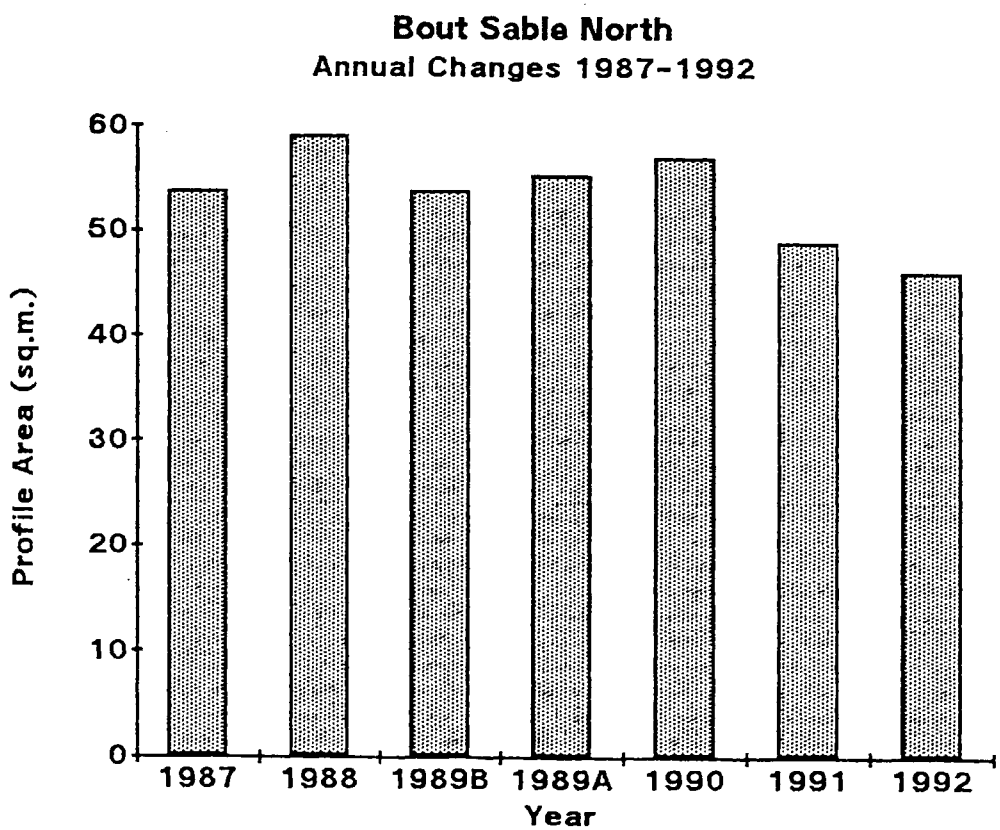


FIGURE 51



BOUT SABLE BEACH (SOUTH) – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in February 1992. This site is located on the eastern coast of Dominica approximately 200m south of Bout Sable North. The beach is exposed to high wave energy for most of the year. The beach consists of sand. Sand mining is conducted near this site on a regular basis. Table 25 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 52. This does not show a clear seasonal trend for an east coast beach where it would be expected to observe erosion during the winter months of December to March and accretion during the summer months of May and August. However, the month of August showed the highest value and the values were generally lower than in December and March. Comparison with the 1988 data for Bout Sable North, shows that both sites exhibit the same behaviour, both accrete at the same time and both erode at the same time.

Annual Changes

Figure 53 shows a bar graph illustrating the annual changes at this site. There was very significant erosion between 1987 and 1988, the beach area decreased by 38%. Since this site is near an active mining area, and since the profile to the north did not exhibit similar behaviour, it is assumed that much of this change is due to sand mining. As at Bout Sable North, there was little change after Hurricanes Gabrielle or Hugo. However, it is relevant to note, that despite some minor fluctuations, this site has shown a marked erosion trend.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -51% and the profile width decreased by -13.346 m or -29%. This represents an erosion rate of -2.7 m per year. However, there is some concern as to the possibility of operator error in the measurement of 18.08.87. So if just the December 1987 value is used instead of the mean for 1987, then the profile area decreased by -34% and the profile width decreased by 12.036 m or -27%. This represents an erosion rate -2.0 m per year. A comparison of the profile area change and the profile width change between Bout Sable North and South indicates that the erosion has been twice as severe at Bout Sable South. While the two sites are located on the same beach, approximately 200m apart, and experience the same wave energy, the profile at Bout Sable South is actively mined for sand. Thus a preliminary assessment of the data appears to indicate that the sand mining has resulted in a twofold increase in erosion at this site.

TABLE 25 DATA RECORD - BOUT SABLE SOUTH
AUGUST 1987 - FEBRUARY 1992

Date	Profile Area (sq.m.)	Profile Width (m.)
18.08.87	61.957	47.944
15.12.87	37.394	45.325
16.03.88	28.133	38.846
31.05.88	21.931	36.778
18.08.88	42.725	46.004
20.12.88	30.023	40.366
28.03.89	26.754	40.557
14.06.89	31.384	41.431
23.08.89	28.446	39.901
----------Hurricanes Gabrielle & Hugo----------		
03.10.89	26.680	34.325
30.11.89	31.278	38.706
18.02.90	17.094	14.658
16.05.90	28.420	40.029
22.08.90	31.273	37.527
03.09.91	29.621	38.518
13.11.91	28.289	38.499
26.02.92	24.527	33.289

DATA SUMMARY BOUT SABLE SOUTH - 1987 - 1992

Year	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m.)
1987	49.676		46.635
1988	30.703	-38	32.999
1989preHG	28.861	- 6	40.630
1989postHG	28.979	0	36.516
1990	25.596	-12	30.738
1991	28.955	+13	38.509
1992	24.527	-15	33.289

FIGURE 52

Bout Sable South
Seasonal Changes 1988

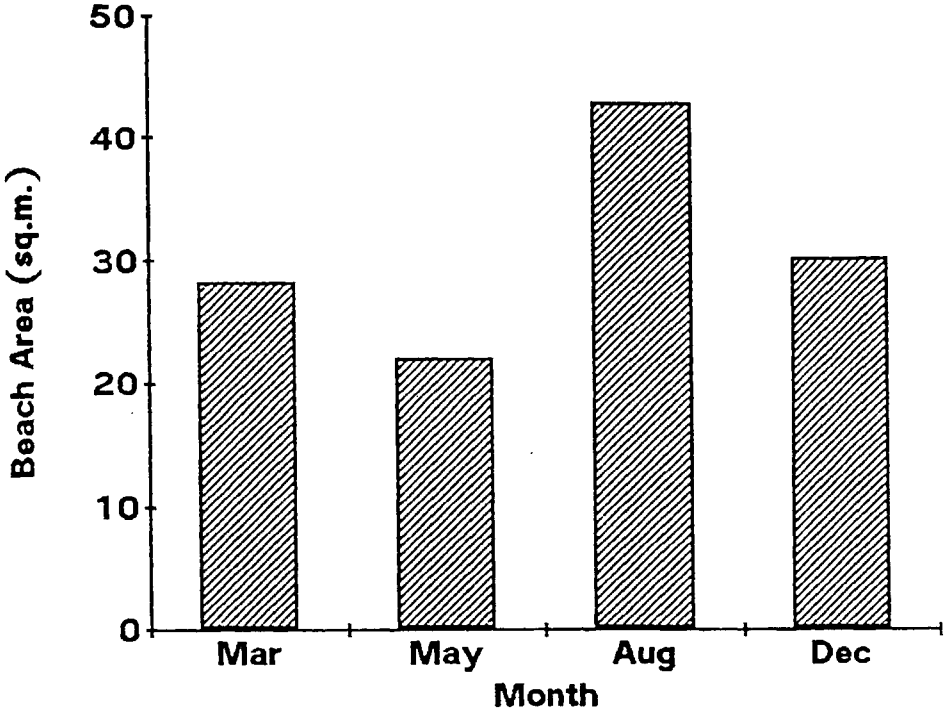
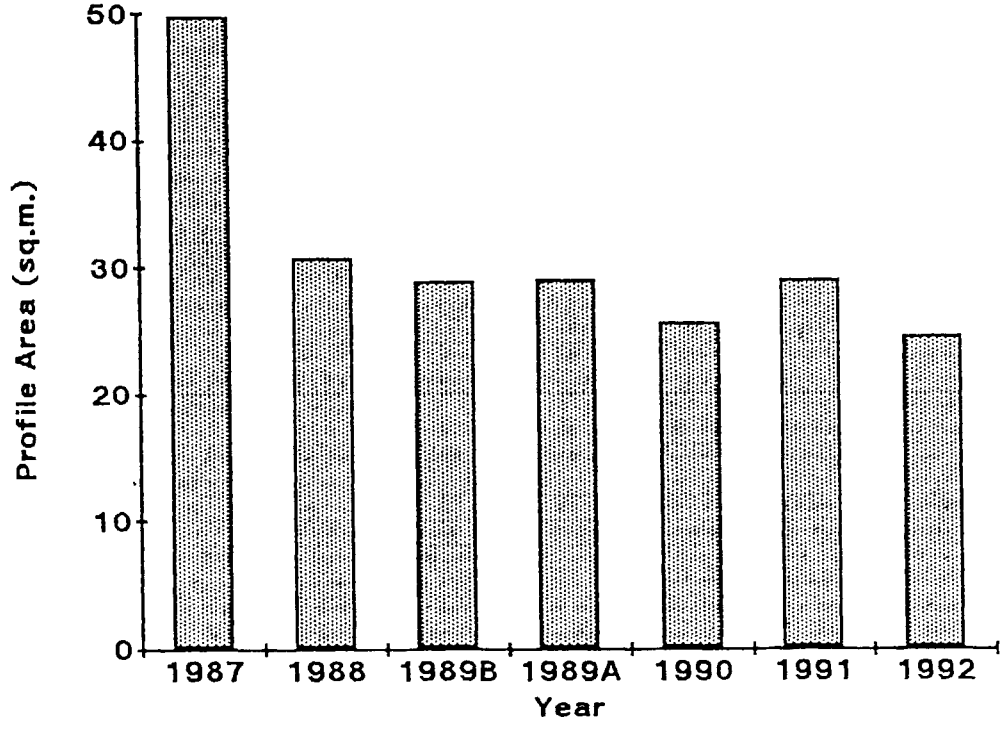


FIGURE 53

Bout Sable South
Annual Changes 1987-1992



DUBUC BAY – BEACH CHANGES 1987 TO 1992

This profile was started in August 1987, and the last measurement recorded was in March 1992. This site is located on the southern coast of Dominica. The beach is exposed to high wave energy for most of the year. The beach consists of stones and large boulders. Table 26 shows the data for this site.

Seasonal Changes

A bar graph illustrating seasonal changes in 1988 is shown in Figure 54. This does show the expected seasonal trend of erosion during the winter months of December to March and accretion during the summer months of May and August.

Annual Changes

Figure 55 shows a bar graph illustrating the annual changes at this site. The mean values for 1987, 1988, 1989 and 1990 show minor fluctuations, but in general the beach was fairly stable. There was no significant erosion following Hurricanes Gabrielle and Hugo in 1989, indeed there was slight accretion. However, in 1991 and 1992 there was significant erosion.

A comparison of the 1987 data with the 1992 data shows that the profile area decreased by -6% and the profile width decreased by -5.316 m or -15%. This represents an erosion rate of -1.1 m per year.

TABLE 26 DATA RECORD - DUBUC BAY
AUGUST 1987 - MARCH 1992

Date	Profile Area (sq.m.)	Profile Width (m.)
13.08.87	80.464	35.711
12.11.87	82.821	36.274
16.03.88	76.861	33.178
11.05.88	92.988	37.340
17.08.88	90.244	39.303
14.03.89	81.751	36.334
27.06.89	81.079	34.807
----------Hurricane Gabrielle & Hugo----------		
26.09.89	85.380	37.335
03.02.90	81.087	33.922
14.08.90	84.468	35.902
15.02.91	74.612	31.709
23.08.91	74.311	30.785
10.12.91	73.386	31.516
09.03.92	76.709	30.677

DATA SUMMARY DUBUC BAY - 1987 - 1992

Year	Mean Profile Area (sq.m.)	% Change in Profile Area	Mean Profile Width (m.)
1987	81.643		35.993
1988	86.698	+ 6	36.607
1989preHH	81.415	- 6	35.571
1989postHH	85.380	+ 5	37.335
1990	82.778	- 3	34.912
1991	74.103	-10	31.337
1992	76.709	+4	30.677

FIGURE 54

Dubuc Bay
Seasonal Changes 1987-88

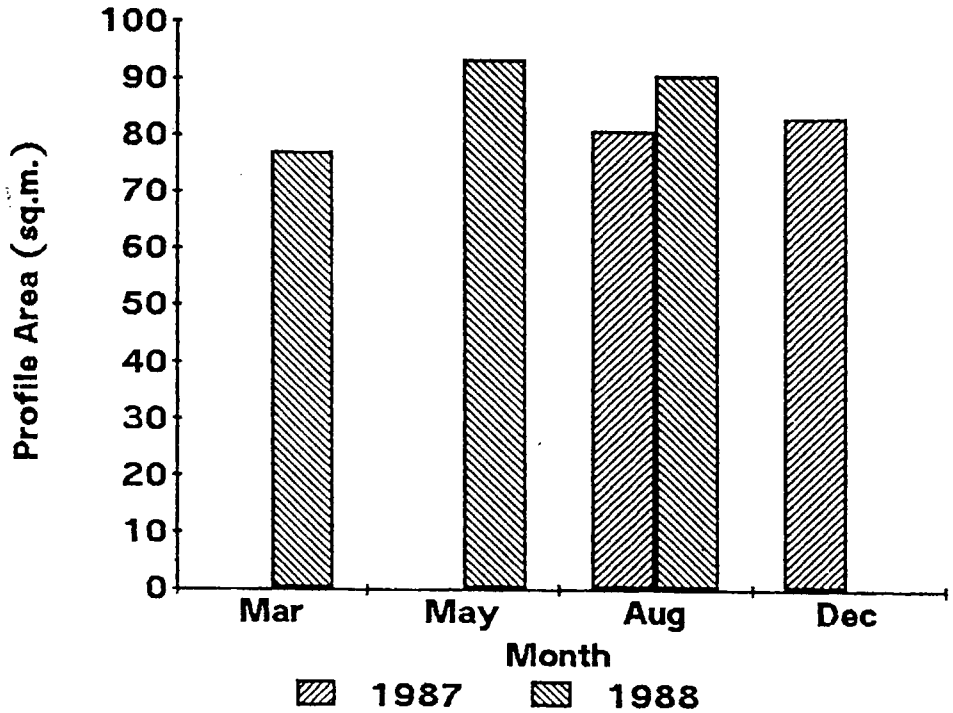
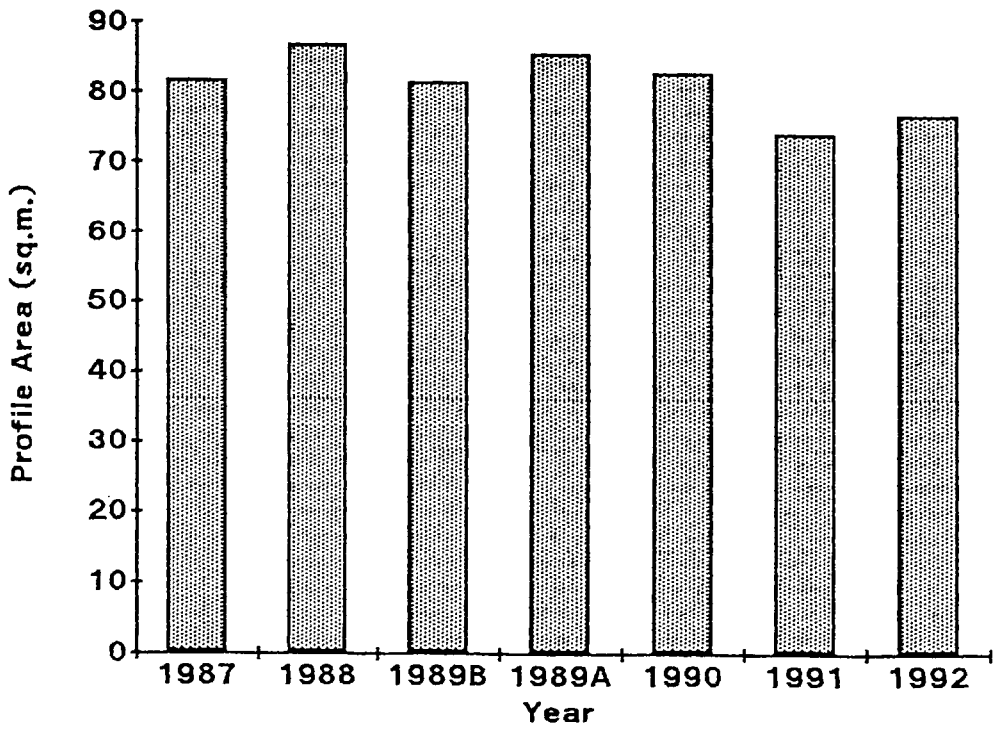


FIGURE 55

Dubuc Bay
Annual Changes 1987-1992



COSALC-I – Beach and Coastal Stability in the Lesser Antilles

This is a regional programme started in 1985 and sponsored by UNESCO which has the ultimate goal to train persons in the Islands to effectively manage their beach resources.

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Reports in this series relating to Dominica are:

#1 Dominica Coastal Monitoring Programme Field Manual (1987)
#2 Dominica Coastal Monitoring Programme Beach Profiling Report (No.1) August 1987 - August 1988 (1990).
#3 Dominica Coastal Monitoring Programme Beach Changes in Dominica 1987 - 1992 (1993).