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COSALC I

BEACH AND COASTAL STABILITY IN THE LESSER ANTILLES

**BEACH CHANGES IN MONTSERRAT  
1990-1993**

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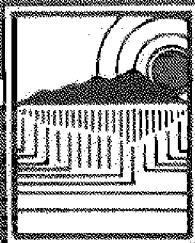
by

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UNESCO - COMAR

UNIVERSITY OF PUERTO RICO  
SEA GRANT COLLEGE PROGRAM



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## 1. SUMMARY

Beach changes have been measured on a regular basis in Montserrat during the period 1990-1993 at ten sites. This report presents and interprets the results of this monitoring program. In September, 1989, Hurricane Hugo, a category 4 hurricane, passed over the island causing tremendous damage to the islands' infrastructure and beaches. The beach monitoring started in February 1990, six months after the hurricane. The data show that all the west coast beaches have shown an accretion trend over this four year period. On average beach area increased by +23% and beach width increased by +6.2 m between 1990 and 1993. This represents an accretion rate of +2.1m/yr.

The most significant accretion took place in 1990 and 1991, since then the rate of accretion has decreased and some beaches have shown erosion. Comparison with data from Dominica, where pre- and post-hurricane data exist, indicates that the Montserrat beaches have achieved as much recovery as possible. Furthermore it appears that the present (1993) size of the beaches is lower than the pre-hurricane values.

The beach recovery in Montserrat may have been further complicated by the extensive sand mining that took place after the hurricane. This was especially evident at Farm's Bay where there was significant erosion for two years after the hurricane. At most west coast sites extensive sand mining also occurred and this will certainly have slowed down the rate of recovery.

Based on the conclusion that the post-hurricane beach recovery phase is over, and that the beaches are probably smaller in size than they were pre-hurricane, it is especially important to continue to control beach sand mining and to promote alternative materials such as crusher dust.

## 2. INTRODUCTION

In September 1989, Hurricane Hugo passed over Montserrat and devastated the island. This hurricane caused severe damage including extensive beach erosion. The rebuilding effort after the hurricane placed further pressure on the depleted beaches as the beaches were mined for construction sand.

The Montserrat beach monitoring program was established in February 1990 with the assistance of the Organization of Eastern Caribbean States Natural Resources Management Unit (OECS-NRMU). Since 1992, the monitoring program has been incorporated into the regional program, COSALC I, Beach and Coastal Stability in the Lesser Antilles. This program is part of the UNESCO COMAR (COastal MARine) project. Since 1993, the COSALC I program has been jointly administered by UNESCO and the University of Puerto Rico Sea Grant College Program (UPR-SGCP).

In Montserrat the counterpart agency is the Ministry of Agriculture, Trade & Environment (MATE). Personnel from this agency carry out the field monitoring and the data analysis. Assistance with the data interpretation and the report preparation is provided by the COSALC I coordinating centre at the UPR-SGCP.

This report discusses the results of the monitoring program during the period 1990-1993, comparisons are also made with the data collected from other islands.

## 3. SITE LOCATION

Ten beaches are monitored in Montserrat, see Figure 1 and Table 1. An eleventh site was established in 1990 near the Fisheries Building at Plymouth, but this was discontinued in 1991 due to the loss of the beach. The beaches are measured every three months.

**FIGURE 1 LOCATION OF THE BEACH MEASUREMENT SITES**

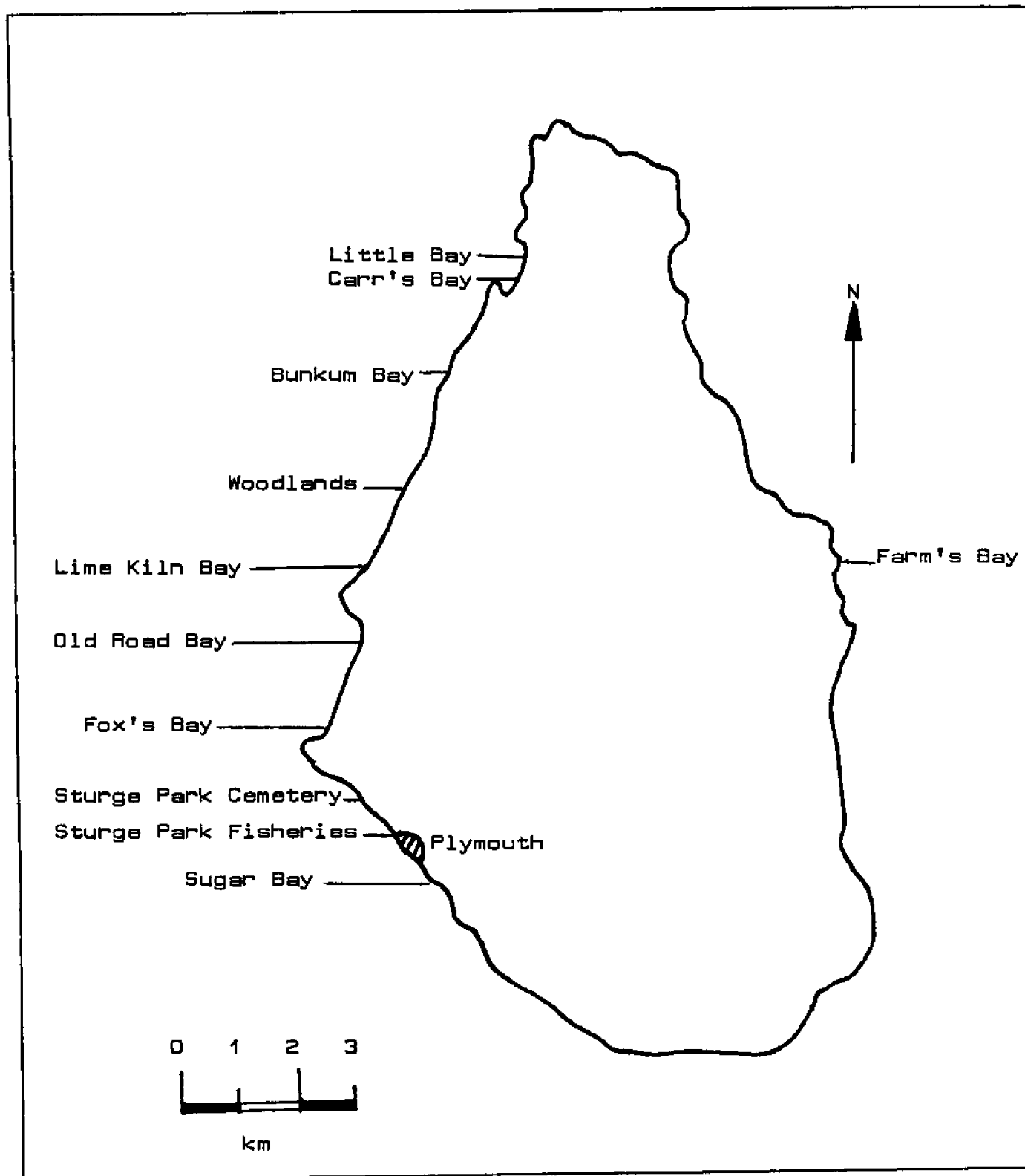


Table 1 Beach Profile Location

| <u>Beach Profile Name</u>        | <u>Date Established</u>                                     |
|----------------------------------|-------------------------------------------------------------|
| Sugar Bay                        | February 1990                                               |
| Sturge Park (Fisheries Building) | February 1990<br>(discontinued Dec. 1991)                   |
| Sturge Park (Cemetery)           | February 1990<br>(New site established<br>July, 1991)       |
| Fox's Bay                        | February, 1990                                              |
| Old Road Bay                     | February, 1990                                              |
| Lime Kiln Bay                    | February, 1990                                              |
| Woodlands                        | February, 1990                                              |
| Bunkum Bay                       | February, 1990                                              |
| Carr's Bay                       | February, 1990                                              |
| Little Bay                       | February, 1990                                              |
| Farm's Bay                       | February, 1990<br>(New site established<br>September, 1992) |

#### 4. METHODOLOGY

Permanent reference points have been established for each beach profile site. The beach profile is measured using an Abney level, tape measure, ranging poles and graduated staff. The profile extends across the beach from the reference point to the offshore step, which is close to the wave breakpoint. Each break of slope of the profile is marked with a ranging pole, and the slope and distance of each segment is measured. The field techniques have been described in detail in a manual, Cambers, 1990.

The analysis is carried out using a macro based on a Lotus spreadsheet programme, which was developed by Dr. D. Gray and Mr. T. Bean of St. Mary's University, Halifax, Canada. This programme calculates the area under the profile and also the width of the profile over a fixed vertical drop.

#### 5. RESULTS

The data have been grouped to determine overall trends, these are discussed in Section 5.1. The individual data for each site are presented in Section 5.2. For each site the data are presented in a table, the annual and seasonal changes are graphed and there is a section on data interpretation.

When comparing the annual data, the 1990 data have been used as the baseline year. The mean data for the following years, 1991,

1992, 1993, have been averaged and compared with the baseline year, 1990, to determine quantitative changes.

Hurricane Hugo passed over Montserrat on 17th September, 1989. This hurricane had sustained winds of 224 km/hr (140 mph) and a tidal surge of up to 3 m. The centre of the hurricane passed over Montserrat and more than 90% of the houses were destroyed/damaged by this category 4 hurricane. The damage to the beaches was also catastrophic. However, there are no quantitative beach profile data for Montserrat prior to the hurricane.

## 5.1 General Analysis

### 5.1.1 Annual Changes

The average changes in profile area and profile width between 1990 and 1993 are shown in Table 2. The changes in profile area for each site are shown in graphs in Figures 2-5.

Table 2 Summary of Beach Changes 1990 - 1993

| Site               | Change in Profile Area 1990-1993 (%) | Change in Profile Width 1990-1993 (m) |
|--------------------|--------------------------------------|---------------------------------------|
| Sugar Bay          | +17.8                                | + 7.3                                 |
| Sturge Park        | + 1.4                                | + 6.5                                 |
| Fox's Bay          | +28.6                                | + 6.5                                 |
| Old Road Bay       | +31.5                                | + 5.0                                 |
| Lime Kiln Bay      | +14.2                                | + 5.0                                 |
| Woodlands Bay      | +52.9                                | + 8.3                                 |
| Bunkum Bay         | +14.6                                | + 6.8                                 |
| Carr's Bay         | +29.9                                | + 1.8                                 |
| Little Bay         | +34.9                                | +10.0                                 |
| Farm's Bay 1990/91 | -13.9                                | -11.0                                 |
| 1992/93            | +21.2                                | +16.1                                 |
| Mean               | +23.3                                | + 6.2                                 |

Figure 2 shows the annual changes in profile area at Sugar Bay, Fox's Bay and Old Road Bay. Both Fox's and Old Road Bays showed significant accretion between 1990 and 1992. However, between 1992 and 1993, the rate of accretion decreased at Old Road Bay, while at Fox's Bay there was erosion. At Sugar Bay, there was a slightly different pattern with accretion between 1990 and 1991, erosion in the following year and then accretion again between 1992 and 1993. At all three sites there was an overall accretion trend over the four years as can be seen by the data in Table 2, the profile area and width increased.



Figure 2

## ANNUAL BEACH CHANGES 1990-1993 Sugar-Fox's-Old Road Bays

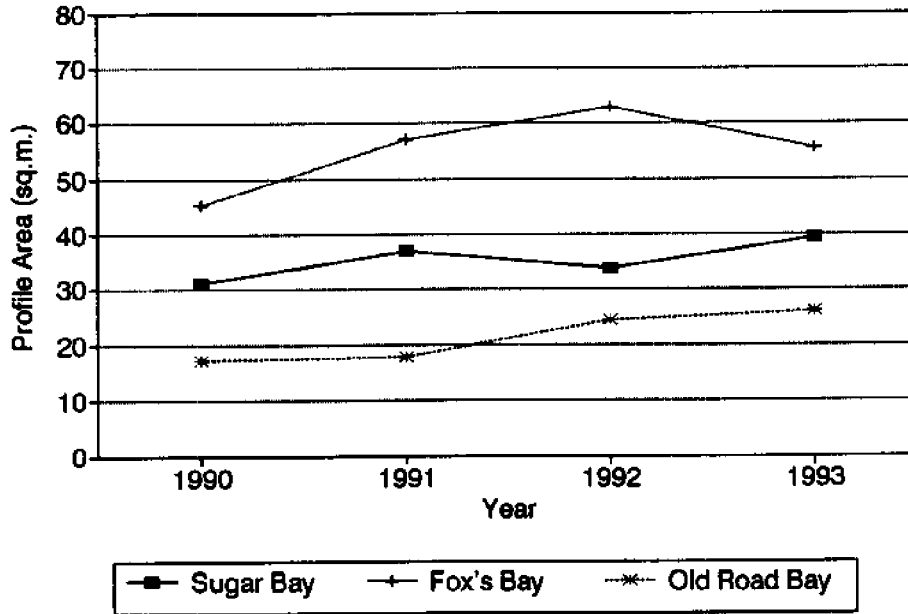


Figure 3

## ANNUAL BEACH CHANGES 1991-1993 Sturge Park

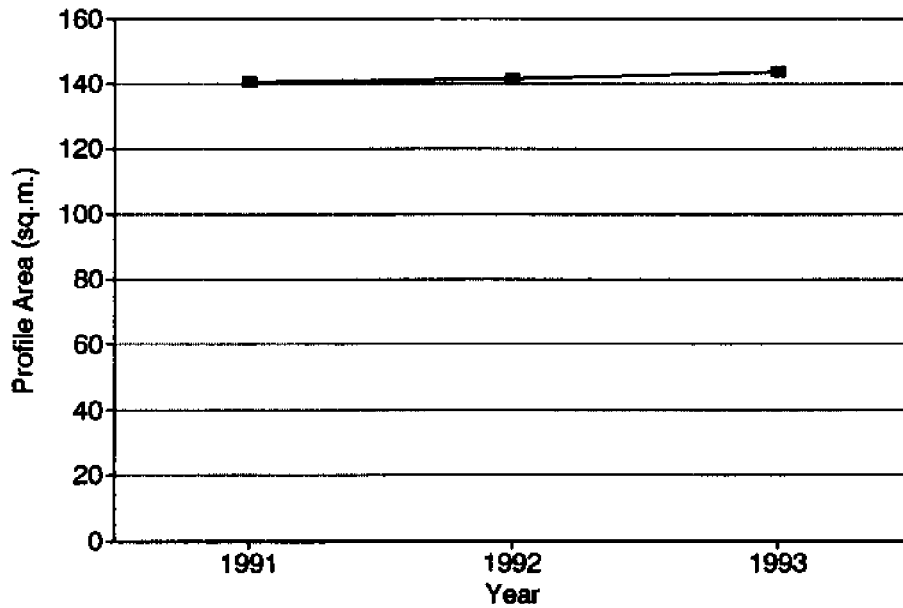


Figure 4

## ANNUAL BEACH CHANGES 1990-1993

Lime Kiln-Woodlands-Bunkum Bay

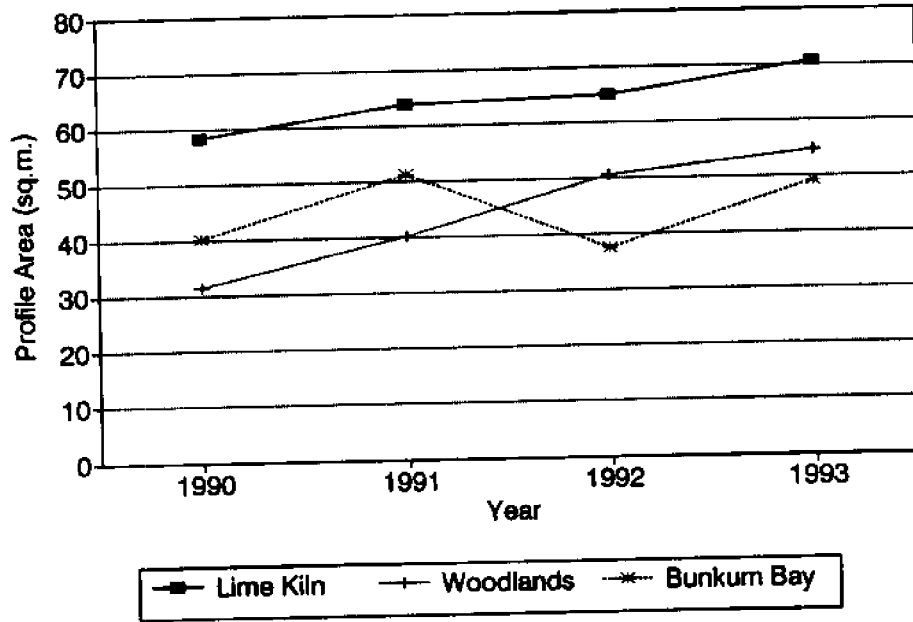


Figure 5

## ANNUAL BEACH CHANGES 1990-1993

Carr's-Little-Farm's Bays

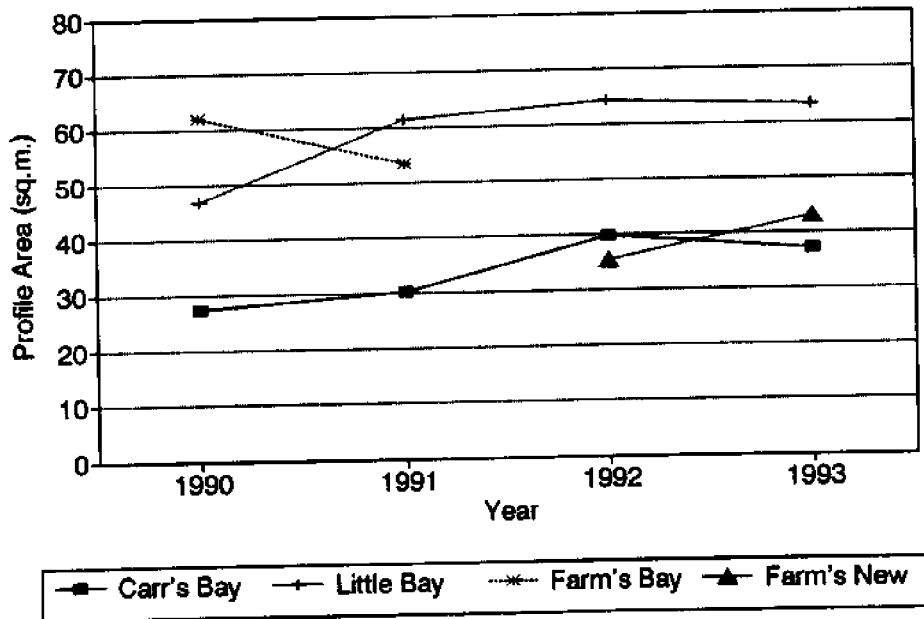


Figure 3 shows the annual changes in profile area at Sturge Park Beach. This site had to be re-established in 1991, so there were no comparable data available for 1990. This site has remained very stable over the three year period, showing just a slight accretion trend.

Figure 4 shows the changes in profile area between 1990 and 1993 at Lime Kiln, Woodlands and Bunkum Bays. Lime Kiln and Woodlands Bays show a similar pattern with steady accretion over the four year period. The accretion was most significant during 1990 and 1991, the rate of accretion was somewhat reduced during 1992 and 1993. At Bunkum Bay, there was accretion during 1990 and 1991, then erosion between 1991 and 1992, followed again by accretion in 1992/1993. The overall trend at all three beaches was for accretion over the four year period as can be seen by the data in Table 2 - the profile width and area increased.

Figure 5 shows the changes in profile area at Carr's, Little and Farm's Bay. Carr's Bay and Little Bay, which are close to each other, show a similar pattern with accretion between 1990 and 1992, and slight erosion between 1992 and 1993. However, the overall trend between 1990 and 1993 was accretion as can be seen from Table 2. At Farm's Bay, the pattern was different, there was significant erosion during 1990 and 1991. This is no doubt related to the fact that this beach was one of the prime sources for construction sand for the rebuilding effort after Hurricane Hugo. The profile site had to be changed in 1992, so there is no continuous four year data span for one site here. The new site showed accretion during the period 1992/1993.

The general trend at all of the sites, with the exception of Farm's Bay, is for accretion over the period 1990-1993. Over the four year period the beaches have increased in area by on average 23%. Similarly the beaches have widened over the four year period by an average total amount of 6.2 m, this represents an accretion rate of +2.1m/yr. Most of the significant accretion took place during the period 1990-1991. Since then the beaches have showed slight accretion or in some cases erosion.

Thus it appears that the major beach recovery from Hurricane Hugo took place during the two years immediately after the storm. Since 1992 the beaches have, in most cases, remained relatively stable, since there were no major storm events in 1992 or 1993.

### 5.1.2 Seasonal Changes

Seasonal changes for all the sites for 1992 and 1993 are discussed individually in Section 5.2. The nine sites on the west coast all show the expected seasonal changes, with accretion during the summer months from June to September and erosion during the winter months from December to March. The erosion is mainly a

result of extra-regional winter swells. The seasonal changes for Farm's Bay on the east coast were not readily apparent mainly because of a break in the data record when the site had to be changed.

## 5.2 Individual Site Data

### SUGAR BAY

| Date      | Beach Area<br>(sq.m) | Beach Width<br>(m) |
|-----------|----------------------|--------------------|
| 26.02.90  | 24.930               | 19.180             |
| 12.06.90  | 33.757               | 25.567             |
| 27.09.90  | 34.842               | 25.257             |
| Mean 1990 | 31.180               | 23.340             |
| 26.03.91  | 25.820               | 19.392             |
| 04.07.91  | 52.916               | 36.914             |
| 16.12.91  | 32.415               | 25.042             |
| Mean 1991 | 37.050               | 27.120             |
| 31.03.92  | 28.685               | 25.866             |
| 08.07.92  | 37.721               | 30.098             |
| 19.09.92  | 38.742               | 41.335             |
| 06.12.92  | 30.084               | 18.680             |
| Mean 1992 | 33.810               | 28.990             |
| 06.04.93  | 33.825               | 31.429             |
| 13.07.93  | 48.810               | 49.162             |
| 04.10.93  | 37.599               | 33.903             |
| 16.12.93  | 37.381               | 28.341             |
| Mean 1993 | 39.400               | 35.710             |

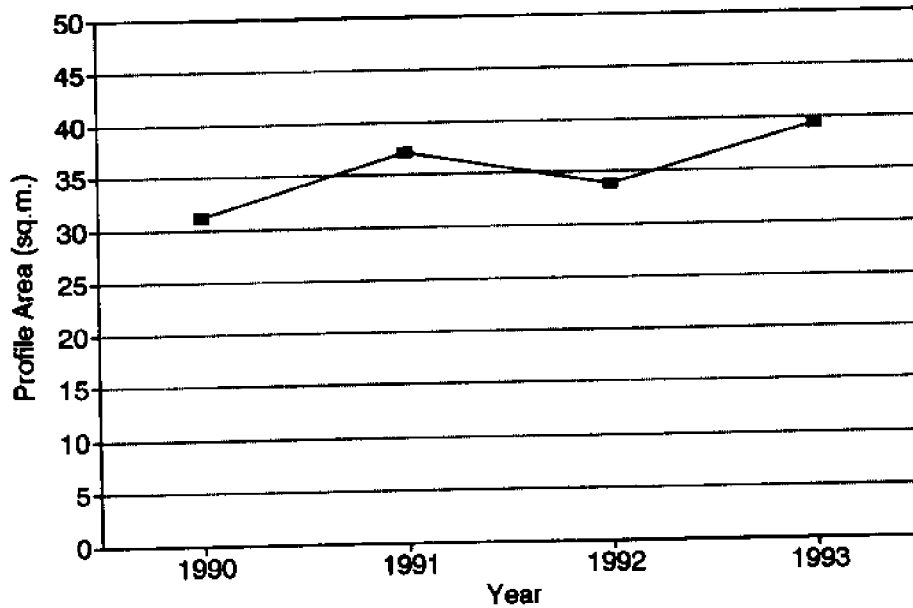
### Data Interpretation - Sugar Bay

There was significant accretion between 1990 and 1991, in the following year there was erosion, and between 1992 and 1993 there was accretion. The general trend was accretion. Between 1990 and 1993, the beach area increased by + 17.8% and the beach width increased by + 7.3 m.

The years 1992 and 1993 showed a clear seasonal pattern, see the second graph on the facing page. In both years there was accretion between June and October and erosion in the winter months, November to April.

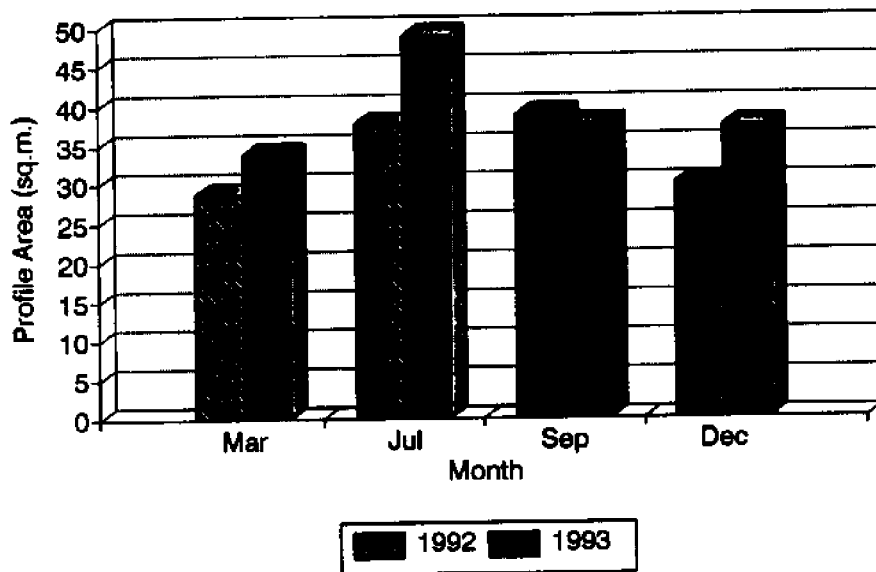
# ANNUAL BEACH CHANGES 1990-1993

Sugar Bay



# Seasonal Changes 1992 & 1993

Sugar Bay



## STURGE PARK

| Date      | Beach Area<br>(sq.m) | Beach Width<br>(m) |
|-----------|----------------------|--------------------|
| 04.07.91  | 132.274              | 44.840             |
| 16.12.91  | 148.980              | 56.199             |
| Mean 1991 | 140.630              | 50.520             |
| 31.03.92  | 126.754              | 48.055             |
| 08.07.92  | 152.264              | 62.632             |
| 19.09.92  | 141.157              | 57.052             |
| 06.12.92  | 145.768              | 60.936             |
| Mean 1992 | 141.490              | 57.170             |
| 06.04.93  | 136.336              | 51.339             |
| 13.07.93  | 144.500              | 56.663             |
| 04.10.93  | 135.725              | 52.336             |
| 16.12.93  | 157.785              | 66.783             |
| Mean 1993 | 143.590              | 56.780             |

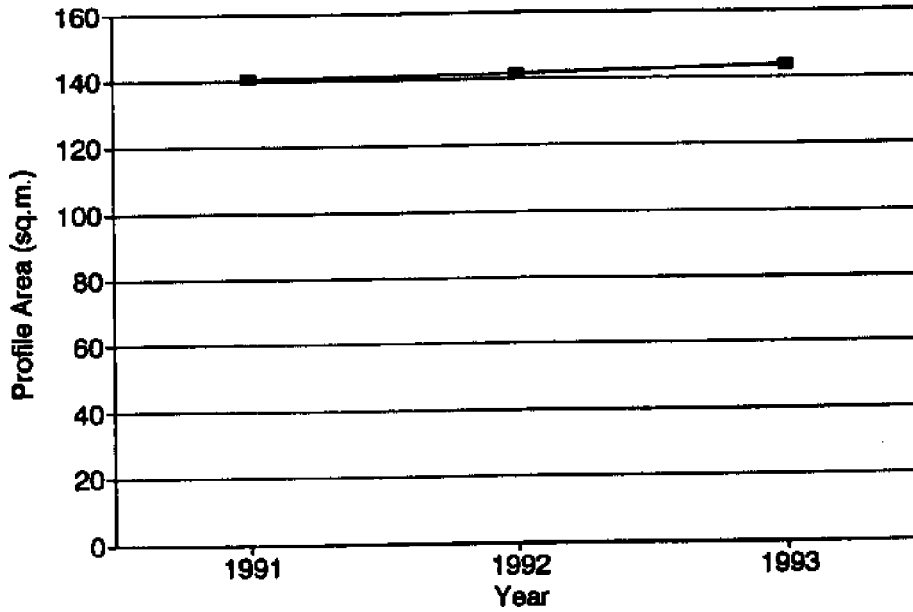
### Data Interpretation - Sturge Park

A new profile had to be set up here in 1991. The reference point is located a considerable distance back from the beach. Between 1991 and 1993, this profile has shown very little change, only slight accretion. The beach area increased by + 1.4%, this low value may be partly due to the fact that the reference point is so far back. Over the same time period the beach width increased by + 6.5 m.

The second graph on the facing page shows the seasonal changes during 1992 and 1993. In both years there was accretion during the months of July and also during December. There was erosion in March.

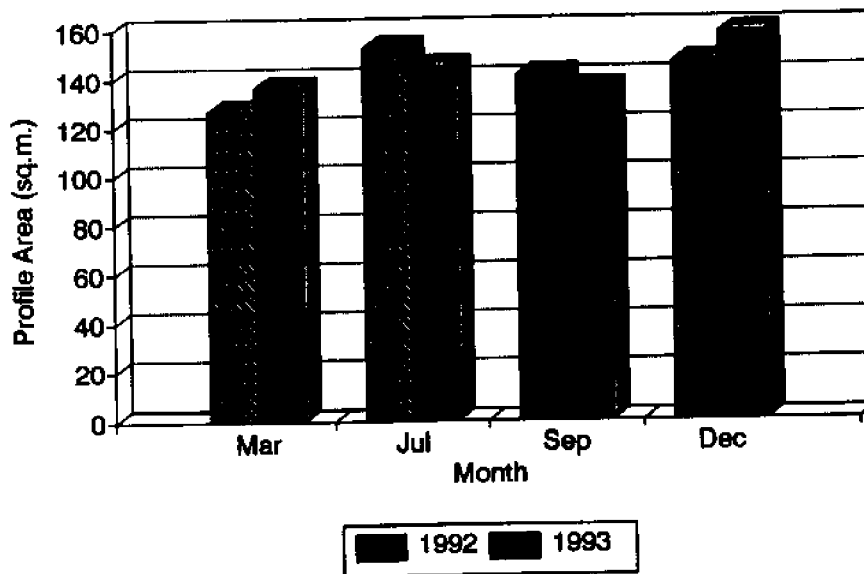
# ANNUAL BEACH CHANGES 1991-1993

Sturge Park



# SEASONAL CHANGES 1992 & 1993

Sturge Park



## FOX'S BAY

| Date      | Beach Area<br>(sq.m) | Beach Width<br>(m) |
|-----------|----------------------|--------------------|
| 26.02.90  | 36.757               | 43.870             |
| 12.06.90  | 54.443               | 44.725             |
| 27.09.90  | 45.295               | 40.681             |
| Mean 1990 | 45.500               | 43.090             |
| 26.03.91  | 62.611               | 46.452             |
| 04.07.91  | 49.121               | 49.121             |
| 16.12.91  | 59.526               | 59.526             |
| Mean 1991 | 57.090               | 51.700             |
| 31.03.92  | 51.365               | 45.350             |
| 08.07.92  | 68.542               | 50.755             |
| 19.09.92  | 57.843               | 46.101             |
| 06.12.92  | 73.716               | 55.017             |
| Mean 1992 | 62.870               | 49.310             |
| 06.04.93  | 60.360               | 49.964             |
| 13.07.93  | 66.999               | 57.394             |
| 04.10.93  | 51.243               | 44.017             |
| 16.12.93  | 43.473               | 39.770             |
| Mean 1993 | 55.520               | 47.790             |

### Data Interpretation - Fox's Bay

There was very significant beach accretion between 1990 and 1991, the accretion continued during 1992 but at a lesser rate. During 1993 there was erosion. The overall trend at Fox's Bay was accretion, between 1990 and 1993, the beach area increased by +28.6% and the beach width increased by + 6.5 m.

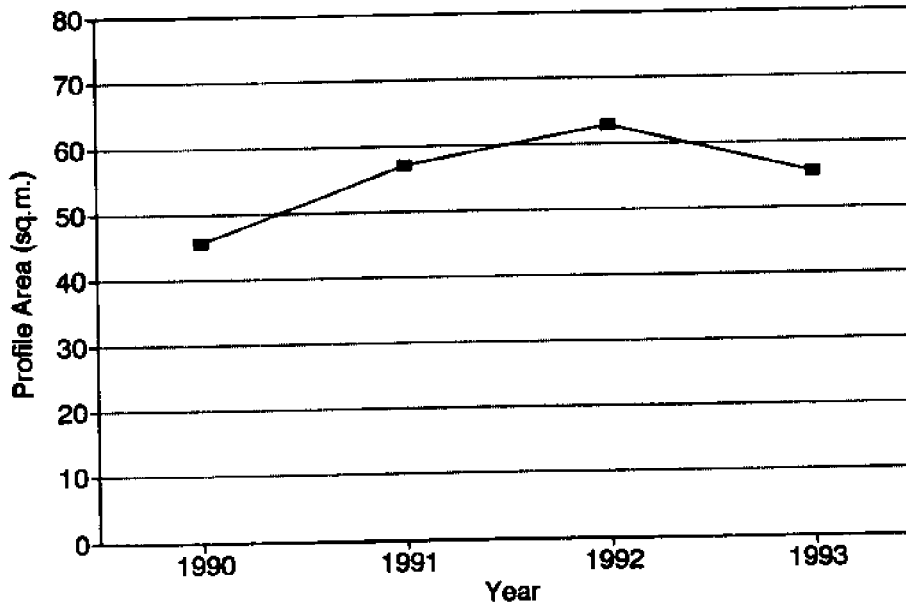
The second graph on the facing page shows the seasonal changes. In general there was accretion in July and erosion from December to March. However, in December 1992, there was significant accretion. This particular measurement was taken during a winter swell event, which apparently brought in sand rather than eroding it.

During 1990 - 1992 active sand mining was taking place at Fox's Bay, the evidence of sand mining pits were noted on the data sheets.



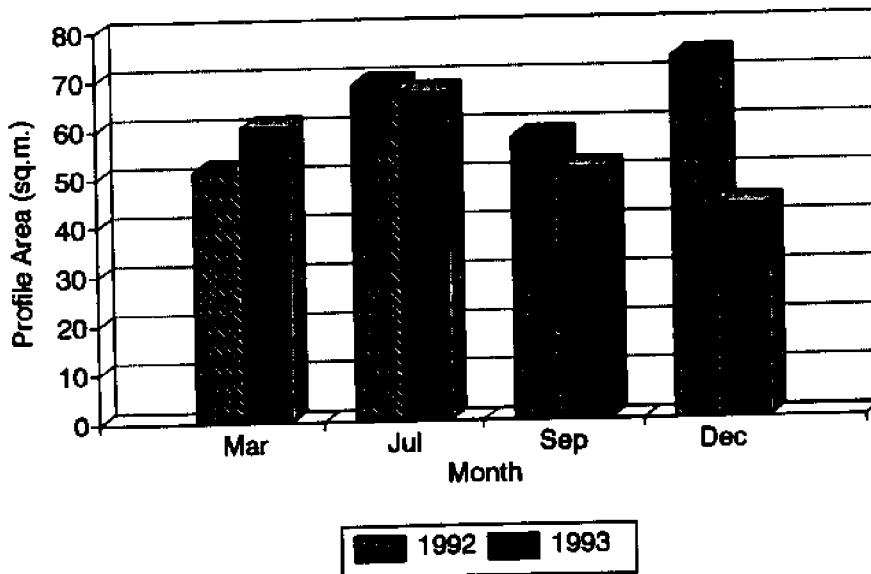
# ANNUAL BEACH CHANGES 1990-1993

Fox's Bay



# SEASONAL CHANGES 1992 & 1993

Fox's Bay



## OLD ROAD BAY

| Date      | Beach Area<br>(sq.m) | Beach Width<br>(m) |
|-----------|----------------------|--------------------|
| 26.02.90  | 19.671               | 17.933             |
| 12.06.90  | 16.253               | 19.621             |
| 27.09.90  | 16.226               | 16.304             |
| Mean 1990 | 17.380               | 17.950             |
| 26.03.91  | 15.610               | 13.998             |
| 04.07.91  | 22.296               | 24.045             |
| 16.12.91  | 15.945               | 21.996             |
| Mean 1991 | 17.950               | 20.010             |
| 31.03.92  | 22.365               | 23.840             |
| 08.07.92  | 28.865               | 30.101             |
| 19.09.92  | 31.834               | 27.901             |
| 06.12.92  | 14.644               | 16.244             |
| Mean 1992 | 24.420               | 24.520             |
| 06.04.93  | 19.954               | 19.524             |
| 13.07.93  | 26.574               | 29.478             |
| 04.10.93  | 34.683               | 30.334             |
| 16.12.93  | 23.507               | 18.036             |
| Mean 1993 | 26.180               | 24.340             |

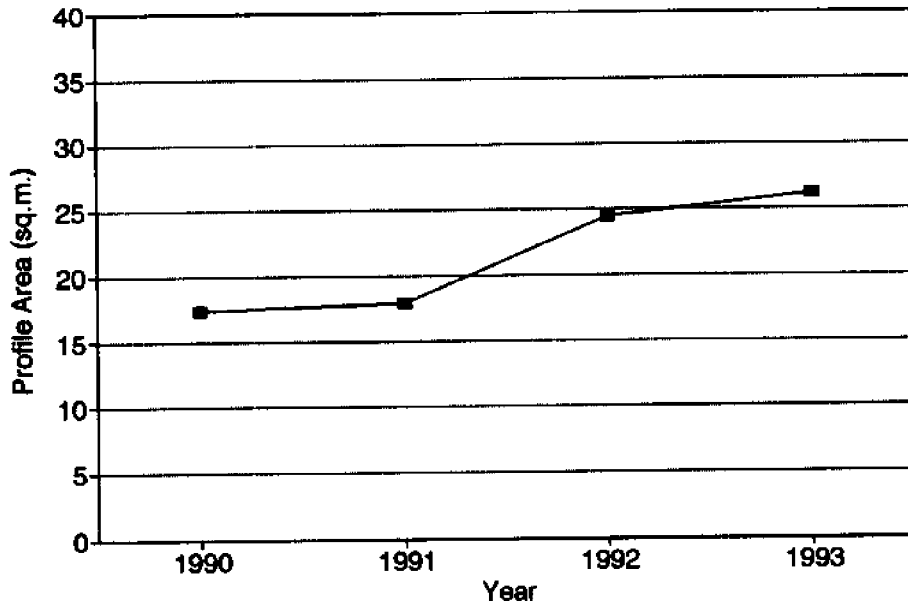
### Data Interpretation - Old Road Bay

Between 1990 and 1991 there was little change at this beach, but significant accretion occurred during 1992. There was only slight accretion between 1992 and 1993. The overall trend was accretion, between 1990 and 1993, the beach area increased by +31.5% and the beach width increased by + 5m.

The seasonal changes for 1992 and 1993 are shown in the second graph on the facing page. The beach at this site showed accretion between July and September, and erosion during the winter months, December to March.

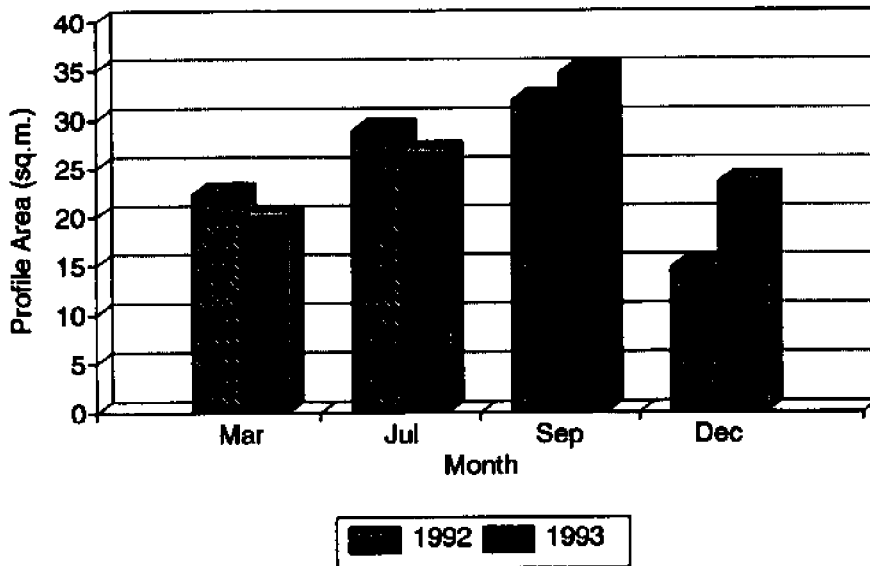
# ANNUAL BEACH CHANGES 1990-1993

Old Road Bay



# SEASONAL CHANGES 1992 & 1993

Old Road Bay



LIME KILN BAY

| Date      | Beach Area<br>(sq.m) | Beach Width<br>(m) |
|-----------|----------------------|--------------------|
| 26.02.90  | 57.412               | 28.550             |
| 12.06.90  | 65.821               | 28.551             |
| 27.09.90  | 51.657               | 23.188             |
| Mean 1990 | 58.300               | 26.760             |
| 26.03.91  | 50.037               | 25.031             |
| 04.07.91  | 92.559               | 36.399             |
| 16.12.91  | 49.185               | 21.819             |
| Mean 1991 | 63.930               | 27.750             |
| 31.03.92  | 60.477               | 29.332             |
| 08.07.92  | 70.748               | 36.068             |
| 19.09.92  | 85.479               | 44.355             |
| 06.12.92  | 43.432               | 20.689             |
| Mean 1992 | 65.030               | 32.610             |
| 06.04.93  | 80.562               | 47.173             |
| 13.07.93  | 74.442               | 35.299             |
| 04.10.93  | 67.163               | 27.929             |
| 16.12.93  | 61.010               | 29.405             |
| Mean 1993 | 70.790               | 34.950             |

Data Interpretation - Lime Kiln Bay

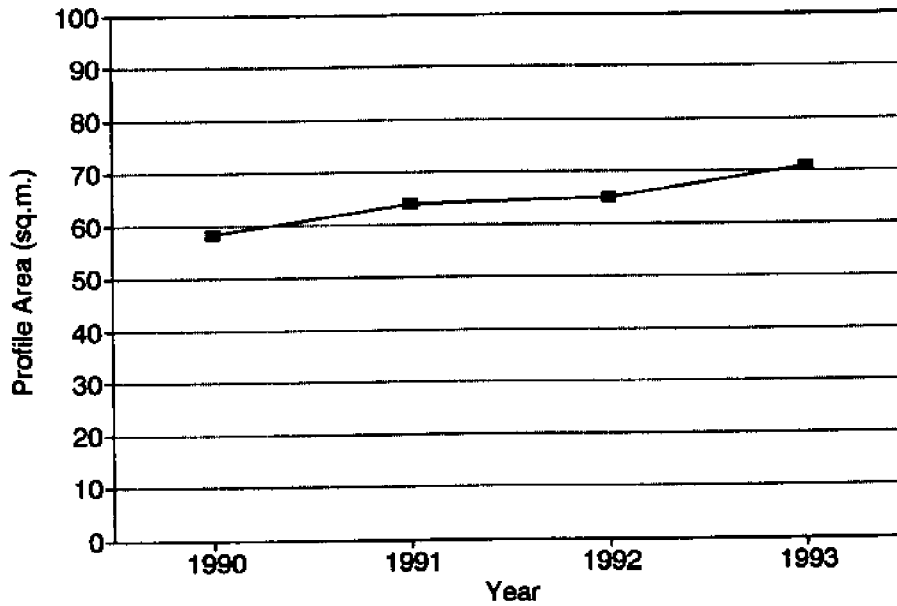
This beach has shown steady accretion over the period 1990-1993. The accretion was most marked during the period 1990/1991 and 1992/1993. The overall trend showed an increase in beach area of +14.2% and an increase in beach width of +5m.

The second graph on the facing page shows the seasonal changes for 1992 and 1993. In general this beach showed accretion in July and September and erosion from December to March. (There was one exception in March 1993 when there was accretion).

This beach varies between stones and sand, generally when the seas are rough the stones predominate, during the rest of the year the sand builds up.

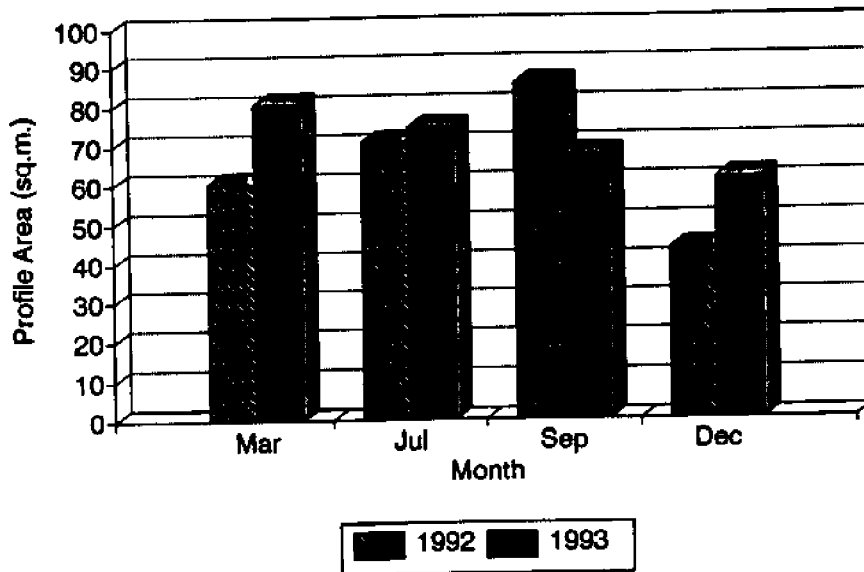
# ANNUAL BEACH CHANGES 1990-1993

Lime Kiln Bay



# SEASONAL CHANGES 1992 & 1993

Lime Kiln Bay



## WOODLANDS

| Date      | Beach Area<br>(sq.m) | Beach Width<br>(m) |
|-----------|----------------------|--------------------|
| 26.02.90  | 27.233               | 22.668             |
| 12.06.90  | 46.905               | 29.091             |
| 27.09.90  | 20.791               | 22.872             |
| Mean 1990 | 31.640               | 24.880             |
| 26.03.91  | 43.281               | 31.455             |
| 04.07.91  | 48.114               | 34.967             |
| 16.12.91  | 29.038               | 27.333             |
| Mean 1991 | 40.140               | 31.250             |
| 31.03.92  | 51.471               | 33.311             |
| 08.07.92  | 59.816               | 31.662             |
| 19.09.92  | 46.999               | 31.360             |
| 06.12.92  | 43.510               | 26.280             |
| Mean 1992 | 50.450               | 30.650             |
| 06.04.93  | 42.343               | 31.112             |
| 13.07.93  | 79.132               | 55.732             |
| 04.10.93  | 53.680               | 32.941             |
| 16.12.93  | 43.088               | 30.251             |
| Mean 1993 | 54.560               | 37.510             |

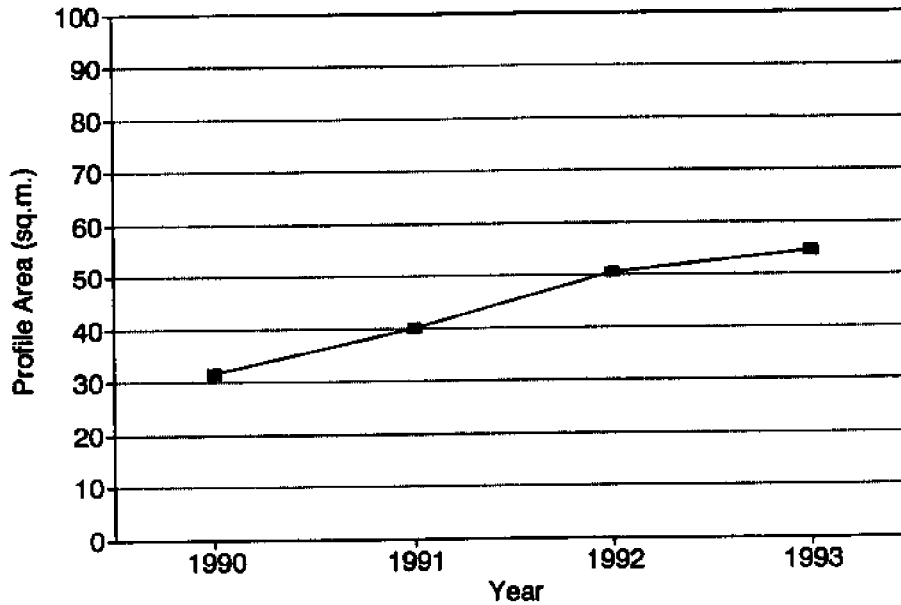
### Data Interpretation - Woodlands Bay

Between 1990 and 1993 this beach showed steady accretion, although between 1992 and 1993 the rate of accretion decreased. Over the four year period the beach area increased by +52.9% and the beach width increased by +8.3 m.

The second graph on the facing page shows the seasonal changes for 1992 and 1993. This site showed the expected pattern with accretion in July and erosion from December to March.

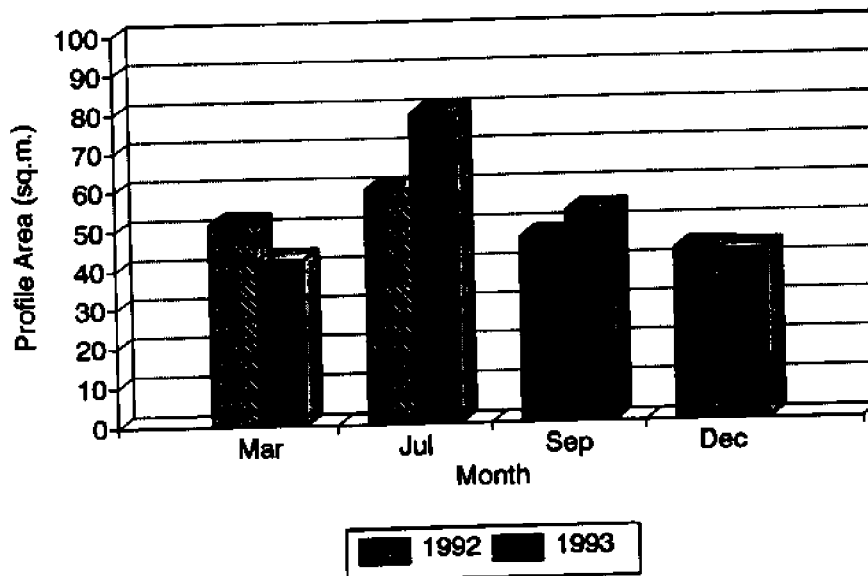
# ANNUAL BEACH CHANGES 1990-1993

## Woodlands Bay



# SEASONAL CHANGES 1992 & 1993

## Woodlands Bay



## BUNKUM BAY

| Date      | Beach Area<br>(sq.m) | Beach Width<br>(m) |
|-----------|----------------------|--------------------|
| 26.02.90  | 32.711               | 30.334             |
| 12.06.90  | 49.744               | 33.955             |
| 27.09.90  | 37.838               | 30.175             |
| Mean 1990 | 40.100               | 31.490             |
| 26.03.91  | 44.803               | 41.102             |
| 04.07.91  | 60.144               | 51.440             |
| 16.12.91  | 48.612               | 39.557             |
| Mean 1991 | 51.190               | 44.030             |
| 31.03.92  | 35.570               | 37.551             |
| 08.07.92  | 44.158               | 34.560             |
| 19.09.92  | 32.187               | 26.488             |
| 06.12.92  | 38.107               | 34.486             |
| Mean 1992 | 37.510               | 33.270             |
| 06.04.93  | 49.004               | 43.403             |
| 13.07.93  | 47.406               | 38.109             |
| 04.10.93  | 61.243               | 36.496             |
| 16.12.93  | 38.920               | 31.935             |
| Mean 1993 | 49.140               | 37.490             |

### Data Interpretation - Bunkum Bay

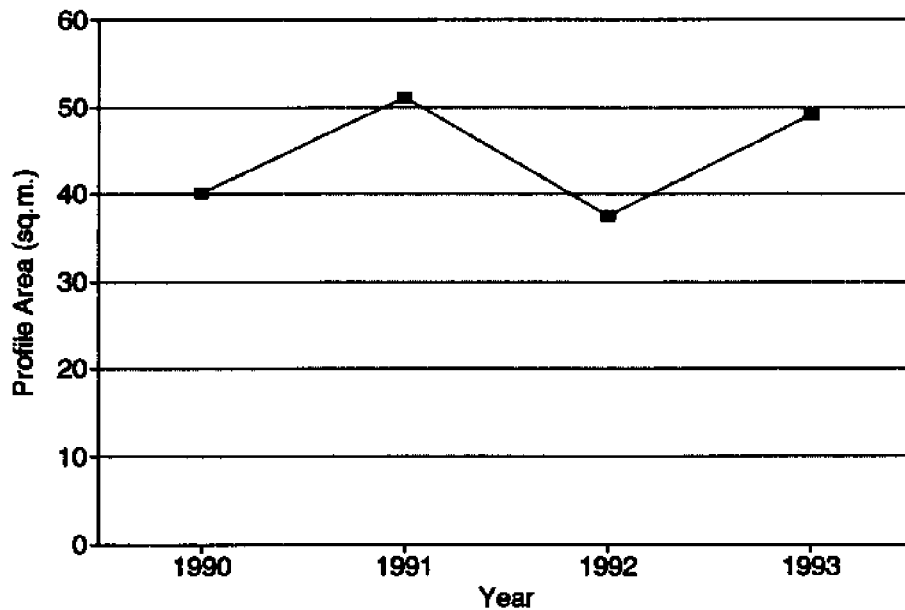
This site showed accretion in 1990 and 1991, erosion in 1992 and accretion again in 1993. The erosion in 1992 may have been partly related to beach sand mining which was noted on the data sheets on at least one occasion. The overall trend from 1990 to 1993 was accretion, the beach area increased by +14.6% and the beach width increased by +6.8m.

The seasonal changes in 1992 and 1993 are shown in the second graph on the facing page. The general trend of accretion between July and September and erosion from December to March was evident, although there were variations between the two years. (In 1992 the main accretion took place in July and in 1993 it took place in September. Similarly the main erosion took place in March in 1992 and in December in 1993).



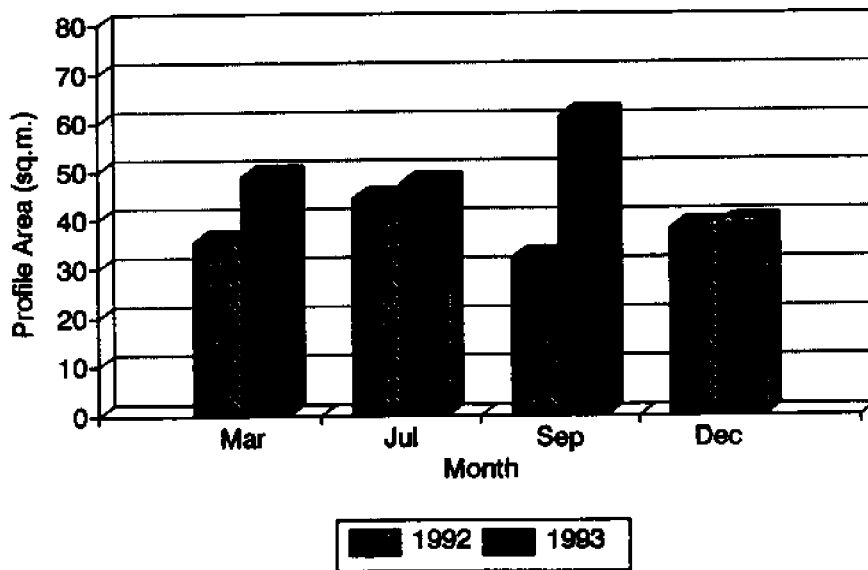
# ANNUAL BEACH CHANGES 1990-1993

## Bunkum Bay



# SEASONAL CHANGES 1992 & 1993

## Bunkum Bay



## CARR'S BAY

| Date      | Beach Area<br>(sq.m) | Beach Width<br>(m) |
|-----------|----------------------|--------------------|
| 26.02.90  | 34.341               | 22.155             |
| 12.06.90  | 22.289               | 23.094             |
| 27.09.90  | 25.956               | 23.731             |
| Mean 1990 | 27.530               | 22.990             |
| 26.03.91  | 25.325               | 18.522             |
| 04.07.91  | 31.736               | 32.515             |
| 16.12.91  | 33.611               | 21.422             |
| Mean 1991 | 30.220               | 24.150             |
| 31.03.92  | 20.909               | 17.030             |
| 08.07.92  | 54.050               | 26.955             |
| 19.09.92  | 58.323               | 26.667             |
| 06.12.92  | 26.084               | 16.013             |
| Mean 1992 | 39.840               | 21.670             |
| 06.04.93  | 40.297               | 34.001             |
| 13.07.93  | 43.673               | 33.630             |
| 04.10.93  | 34.093               | 26.668             |
| 16.12.93  | 30.734               | 19.099             |
| Mean 1993 | 37.200               | 28.350             |

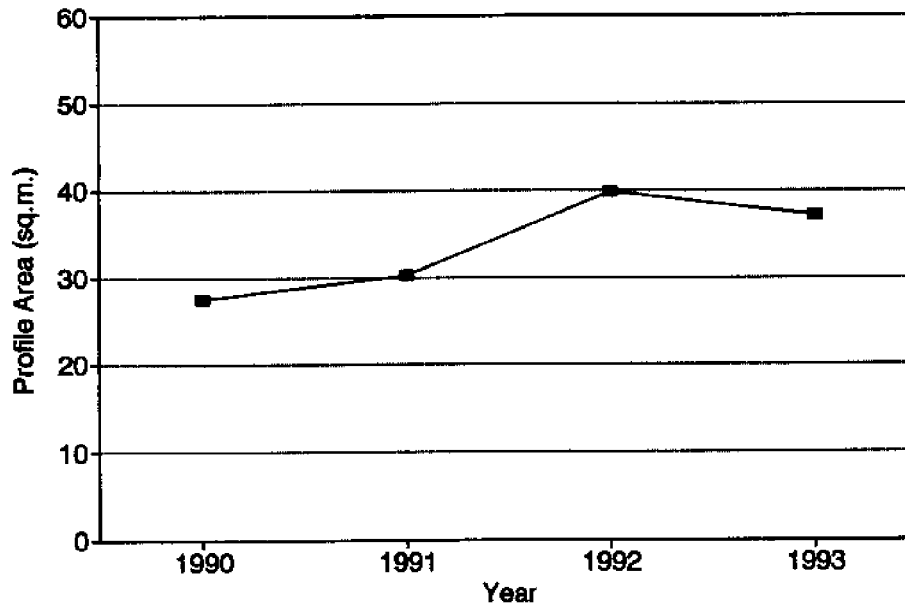
### Data Interpretation - Carr's Bay

Between 1990 and 1991 there was slight accretion, between 1991 and 1992 there was significant accretion, however, between 1992 and 1993 there was erosion. Sand mining at this site was observed in 1990. The overall trend has been accretion, the beach area increased between 1990 and 1993 by +29.9% and the beach width increased by +1.8 m.

The seasonal changes, seen in the second graph on the facing page, showed accretion between July and September and erosion between December and March.

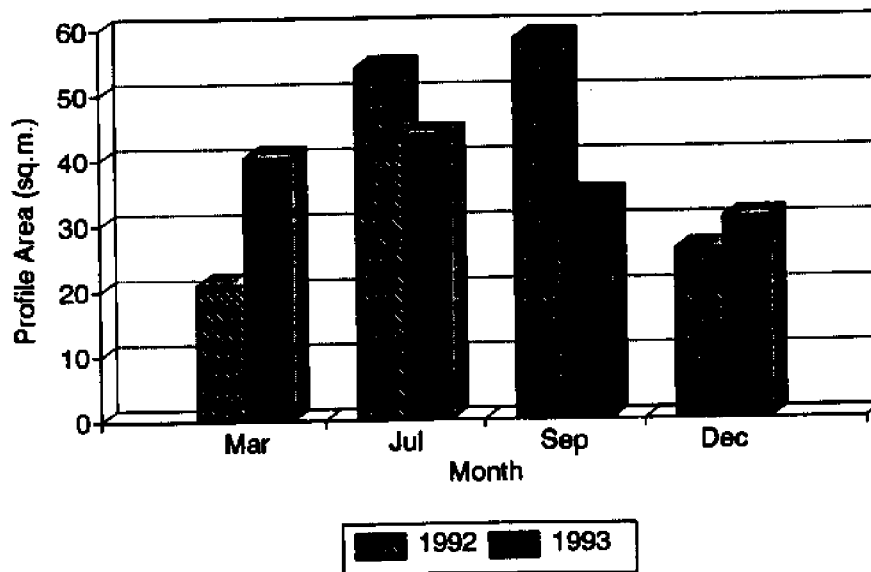
# ANNUAL BEACH CHANGES 1990-1993

Carr's Bay



# SEASONAL CHANGES 1992 & 1993

Carr's Bay



## LITTLE BAY

| Date      | Beach Area<br>(sq.m) | Beach Width<br>(m) |
|-----------|----------------------|--------------------|
| 26.02.90  | 43.530               | 30.058             |
| 12.06.90  | 48.649               | 32.044             |
| 27.09.90  | 48.043               | 35.353             |
| Mean 1990 | 46.740               | 32.490             |
| 26.03.91  | 67.312               | 42.254             |
| 04.07.91  | 65.574               | 57.697             |
| 16.12.91  | 51.505               | 33.720             |
| Mean 1991 | 61.460               | 44.560             |
| 31.03.92  | 52.627               | 39.487             |
| 08.07.92  | 64.696               | 39.215             |
| 19.09.92  | 86.556               | 42.089             |
| 06.12.92  | 53.341               | 31.326             |
| Mean 1992 | 64.310               | 38.030             |
| 06.04.93  | 61.400               | 47.677             |
| 13.07.93  | 68.787               | 47.210             |
| 04.10.93  | 63.674               | 48.815             |
| 16.12.93  | 59.835               | 35.572             |
| Mean 1993 | 63.420               | 44.820             |

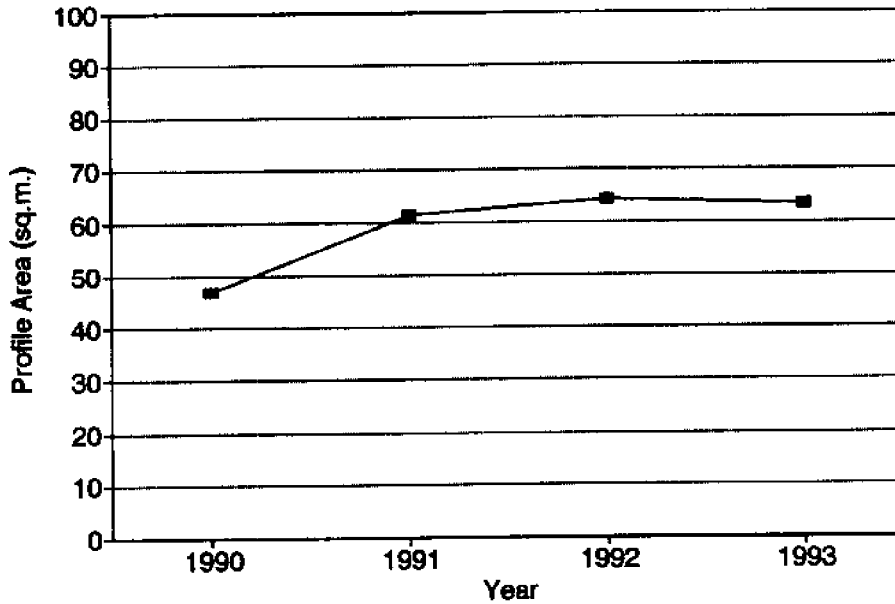
### Data Interpretation - Little Bay

This beach showed significant accretion between 1990 and 1991, since then the beach has remained stable with only very slight accretion. Evidence of sand mining was noted in 1992 and 1993. The overall trend has been accretion and the beach area increased by 34.9% between 1990 and 1993 and the beach width increased by 10.0 m over the same period.

The seasonal changes, seen in the second graph on the facing page, showed accretion between July and September and erosion between December and March.

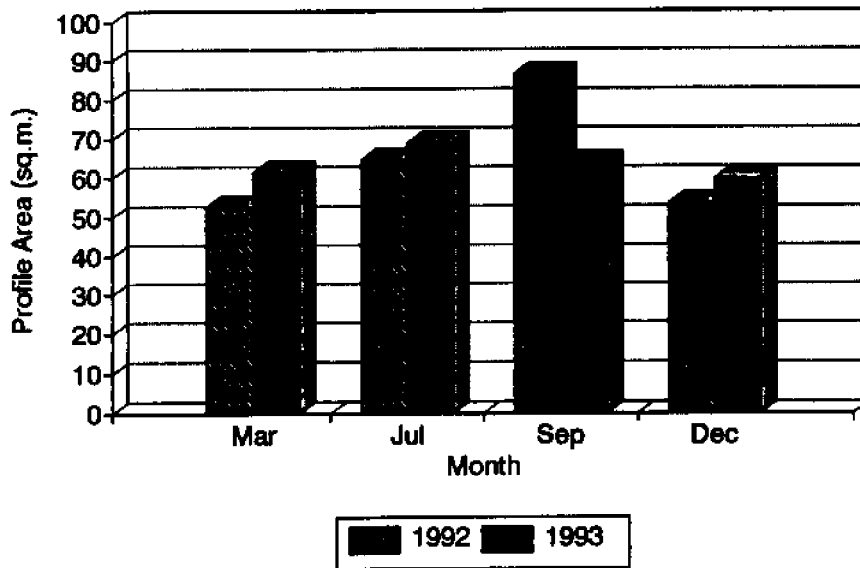
# ANNUAL BEACH CHANGES 1990-1993

## Little Bay



# SEASONAL CHANGES 1992 & 1993

## Little Bay



FARM'S BAY

| Date                      | Beach Area<br>(sq.m) | Beach Width<br>(m) |
|---------------------------|----------------------|--------------------|
| 26.02.90                  | 70.621               | 47.686             |
| 12.06.90                  | 68.867               | 47.676             |
| 27.09.90                  | 47.082               | 31.869             |
| Mean 1990                 | 62.190               | 42.410             |
| 26.03.91                  | 58.580               | 39.400             |
| 04.07.91                  | 37.721               | 1.995              |
| 16.12.91                  | 64.306               | 52.722             |
| Mean 1991                 | 53.540               | 31.372             |
| 31.03.92                  | 48.467               | 40.985             |
| 08.07.92                  | 85.552               | 91.070             |
| Mean 1992                 | 67.010               | 66.030             |
| New Profile established : |                      |                    |
| 19.09.92                  | 30.071               | 34.971             |
| 06.12.92                  | 40.810               | 41.717             |
| Mean 1992                 | 35.440               | 38.340             |
| 06.04.93                  | 69.948               | 91.797             |
| 13.07.93                  | 36.587               | 50.050             |
| 04.10.93                  | 33.563               | 37.092             |
| 16.12.93                  | 31.782               | 38.790             |
| Mean 1993                 | 42.970               | 54.430             |

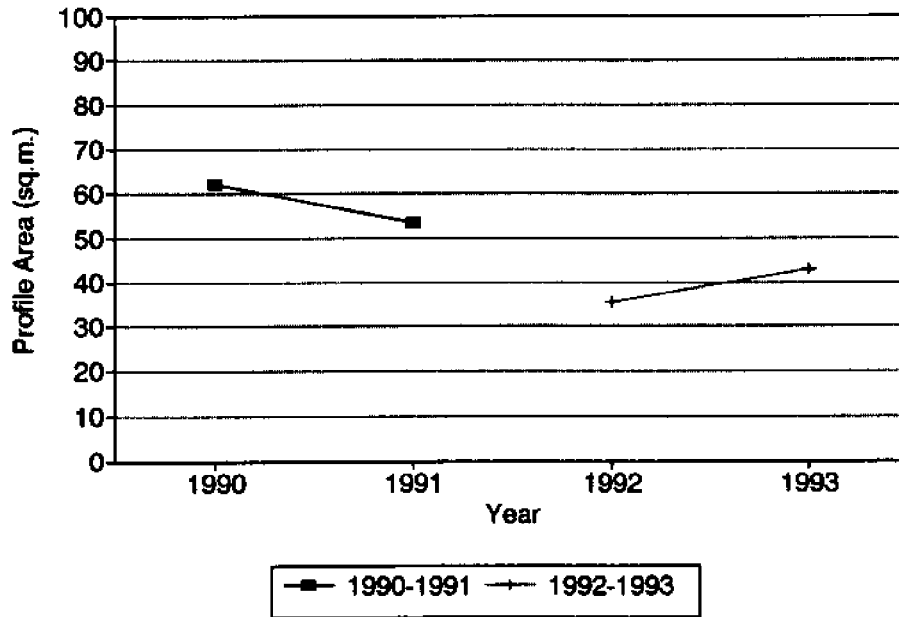
Data Interpretation - Farm's Bay

Between 1990 and 1991 this site showed significant erosion which probably reflects the extensive sand mining which took place at Farm's Bay during this period. The beach area decreased by -13.9% and the beach width decreased by -11.0 m. A new profile had to be established in 1992 due to the removal of the reference point. Between 1992 and 1993 the site showed accretion, although these data must be treated with caution since there were only two measurements for 1992. During this period the beach accreted by +21.2% and the beach width increased by +16.1m.

The seasonal changes are difficult to interpret for this site since there was only one year, 1993, when four measurements were made. During 1993 there was significant accretion in March, during the remainder of the year, the beach area remained the same.

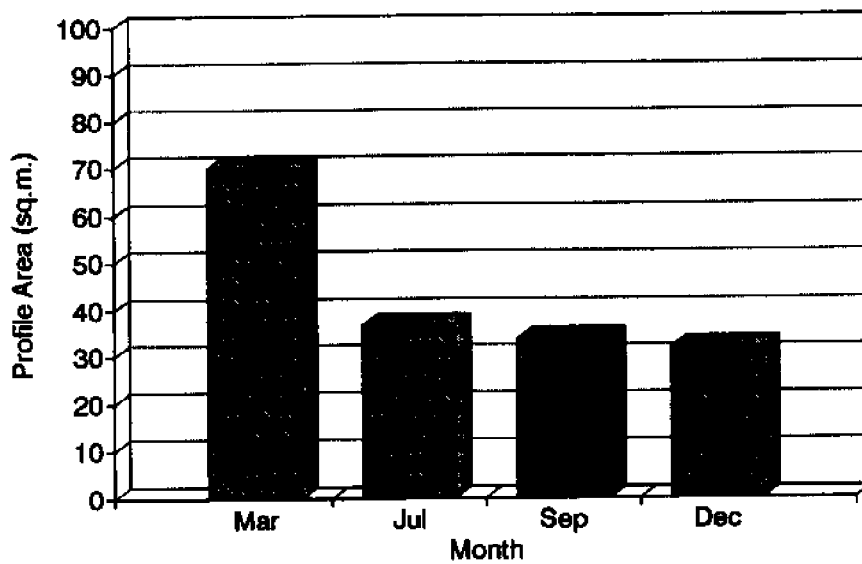
# ANNUAL BEACH CHANGES 1990-1993

Farm's Bay



# SEASONAL CHANGES 1993

Farm's Bay



## 6. DISCUSSION

The monitoring program in Montserrat was established after Hurricane Hugo and unfortunately there are no pre-hurricane data available. Before discussing the Montserrat data, it is useful to look at data from another island where pre- and post-hurricane data exist.

A coastal monitoring program was established in Dominica in 1987. Although the actual centre of Hurricane Hugo did not pass over Dominica, as was the case with Montserrat, the centre passed 80 km (50 miles) north of Dominica and caused serious damage both to infrastructure and beaches.

Figure 6 shows the changes in beach area at four sites on the west coast of Dominica over the period 1987-1992, Cambers & James (1993). There was serious erosion after the hurricane see the trough in the graphs at 1989A. In 1990 there was significant accretion. This accretion continued in 1991 and 1992, but at a lesser rate. There is a close similarity of Figure 6 (1989A to 1992) to the Montserrat graphs shown in Figures 2-5.

Another important feature of the graph in Figure 6 for Dominica, is that the beaches never recovered fully to their pre-hurricane levels. Thus while there was erosion during the hurricane and accretion afterwards, the beaches never fully recovered, thus it is likely that sand was lost to deep water offshore where it can never be moved by normal waves. In Dominica, the hurricane had a permanent and lasting effect on the beaches.

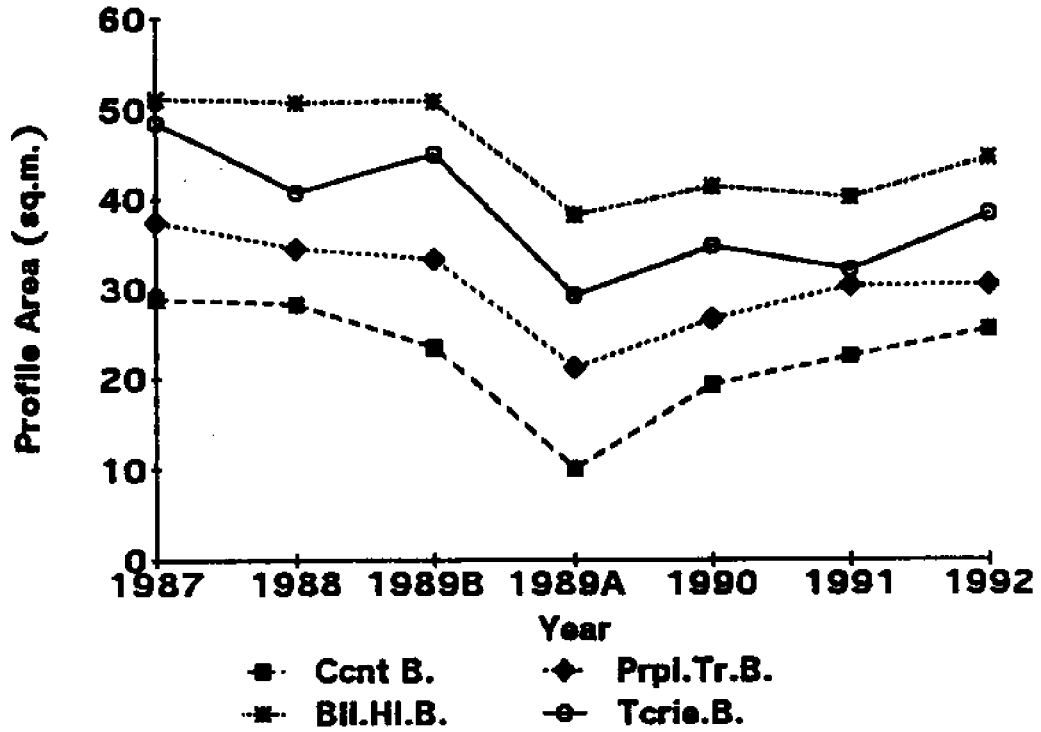
Since there are no pre-hurricane data for Montserrat, it is useful to try and combine the data for Montserrat and Dominica. It appears that in Montserrat there was significant accretion in 1990 and 1991 following Hurricane Hugo, however, in 1992 and 1993 this accretion rate has decreased and at some sites erosion has become evident. Thus it would appear that the Montserrat beaches have achieved as much recovery as possible. Furthermore based on inference from the Dominica data, it appears likely that the present (1993) size of the beaches is lower than the pre-hurricane values.

The beach recovery in Montserrat may have been further complicated by the extensive sand mining that took place after the hurricane. This was especially evident at Farm's Bay where there was significant erosion for two years after the hurricane. At most west coast sites extensive sand mining also occurred and this will certainly have slowed down the rate of recovery.



Figure 6 Beach Changes on the West Coast of Dominica 1987-1992

Source : Cambers & James (1993)



## 7. CONCLUDING REMARKS

The beach monitoring program in Montserrat has provided some useful information on the recovery of the beaches after Hurricane Hugo. However, the data indicate that the recovery phase is now over. It is most likely that existing (1993) beach areas are less than pre Hurricane Hugo areas. Against this background it is especially important to continue to control beach sand mining and to promote other materials such as crusher dust.

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## REFERENCES

Cambers, G. 1990. Montserrat Coastal Monitoring Programme Field Manual. Prepared for the OECS-NRMU.

Cambers, G., James, A. 1993. Dominica Coastal Monitoring Programme Beach Changes in Dominica 1987-1992. Prepared for UNESCO COMAR COSALC I.

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