

# SHORELINE CHANGES IN THE SOUTH CHANDELEUR ISLANDS BARRIER ARC- 1887 TO 1996 PLAQUEMINES PARISH, LOUISIANA

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## INTRODUCTION

The U.S. Geological Survey (USGS), in cooperation with the Coastal Research Laboratory in the Department of Geology and Geophysics at the University of New Orleans (UNO) and the Center for Coastal Energy and Environmental Resources at Louisiana State University (LSU), is investigating the processes of coastal erosion and wetland loss in Louisiana (Sallenger and others, 1987; Sallenger and Williams 1989; Penland and others, 1992). Building on the USGS Louisiana Barrier Island Study (Williams and others, 1992), this USGS Open-File Report depicts shoreline changes between 1869 and 1996, which provides a 7.9-year update of McBride and others (1992). In order to quantify shoreline changes since 1989, new vertical aerial mapping photography was acquired on December 9, 1996. The methods and transects used by McBride and others (1992) were used to insure data compatibility of the new measurements and analysis. Tables 1 and 2 presents the transect measurements of shoreline change for the South Chandeleur Islands. For gulfside change measurements, a negative (-) sign signifies landward movement or erosion and a positive (+) sign signifies a seaward movement or progradation. For bayside change measurements, a negative (-) sign signifies a seaward movement or erosion and a positive (+) signifies a landward movement or accretion.

The South Chandeleur Islands are located approximately 100 km southeast of New Orleans (Figure 1). The South Chandeleur Islands are part of the Chandeleur Island barrier system and provide the seaward protective boundary for St. Bernard Parish (Kwon, 1996; Kahn, 1980; Nummedal and others, 1980; Kahn and Roberts, 1982; Penland and others, 1985; Suter and others, 1988; Ritche and others, 1991). Three tidal inlets, Breton Island Pass, Grand Gosier Pass, and Curlew Island Pass, connect the Gulf of Mexico to Breton and Chandeleur Sounds. The South Chandeleur Islands are fragmented into three groups of small ephemeral islands and shallow shoals that are separated by wide tidal inlets (McBride and others, 1992). Grand Gosier is not present in the 1869 map. Either the island did not exist or the original survey accidentally missed the island. Since 1869, Breton Island has displayed a typical horseshoe shape whose resistant ends tend to anchor the island while leaving the central portion susceptible to breaching. By 1951, Errol Island (1869 map) had disappeared and Grand Gosier Island had formed between Breton and Curlew Islands (McBride and others, 1992). By 1978, Curlew Island, the northern most of the South Chandeleur Islands, grew into the arcuate shape that characterizes the island today. A large fetch is available across Breton and Chandeleur Sounds capable of producing enough wave energy to form well developed,

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barred beaches along the bay shorelines of south and north Grand Gosier islands and Curlew Island. On the northern end of south Grand Gosier, bayside wave energy may be more dominant than gulfside wave energy, thus producing the recurved spit (McBride and others, 1992). In August of 1969, the South Chandeleur Islands were devastated by Hurricane Camille; a category 5 hurricane that produced wind speeds of 190-200 mph and a storm surge exceeding 20 feet. This extreme natural disaster caused extensive erosion and breaching making the islands more susceptible to subsequent storm events.

## **SHORELINE MOVEMENT**

The magnitude and rate of change for the South Chandeleur Islands were derived from 120 shore-normal transects along the gulf and bay shorelines (Transect Map, Tables 1&2). Comparisons of shoreline position are made for the periods 1869 vs. 1989; 1989 vs. 1996; and 1869 vs. 1996. The overlay maps illustrate land loss and quantitative changes for the South Chandeleur Islands. To maintain compatibility with the 1992 study by McBride and others, the gulf and bay shoreline change measurements of two island groups, Breton Island, Grand Gosier and Curlew Island were analyzed. In addition to the separate analysis of the two island groups, the South Chandeleur Barrier Islands' shoreline movement was studied as a whole.

## **GULFSIDE SHORELINE CHANGES**

For the 127-year period between 1869 and 1996, long-term gulf shoreline transects for Breton Island measured between -662m and -1297m (Table 1, 1869-1996, transects 1-12). The average shoreline change was determined to be -939.6m, which equals a rate of -7.4m/yr (Table 3). Grand Gosier Island was not mapped in 1869; therefore, long-term shoreline change measurements did not apply. Curlew Island measured long-term shoreline movement between -1843m and -2519m (Table 1, 1869-1996, transects 16-53). An average shoreline change was calculated to be -2057.4m for a rate of -16.2m/yr (Table 3). As a whole, the South Chandeleur Islands' long-term range of shoreline movement was between -662m and -25519m (Table 1, 1869-1996). The south islands' shoreline moved an average of -1638.2m at a rate of -12.9m/yr (Table 3). The short-term shoreline movement was calculated for the 7.9-year period between 1989 and 1996. During this time, Breton Island's gulf shoreline migrated between -15m and -351m (Table 1, 1989-1996, transects 1-12). The average shoreline change was found to be -124.9m at a rate of -15.8m/yr (Table 3). Grand Gosier's and Curlew Island's gulf shoreline change reached between 334m and -221m (Table 1, 1989-1996, transects 16-53) for an average shift of -5.7m at a rate of -0.7m/yr (Table 3). The short-term analysis for the entire South Chandeleur system yielded gulf shoreline migration between 334m and -351m (Table 1, 1989-1996). The average change was determined to be -40.0m at a rate of -5.6m/yr (Table 3).

Previous work by McBride and others (1992) documented long-term shoreline change between years 1869 and 1989 (120 years) and short-term change between years 1978 and 1989 (11 years). This earlier analysis reported a long-term shoreline change rate for Breton Island of -5.7m/yr (Table 3) and a short-term change rate of -4.1m/yr (Table 3).

Compared to this recent study, the long-term gulf shoreline erosion rate increased by 1.7m/yr; changing from  $-5.7\text{m/yr}$  (1869-1989) to  $-7.4\text{m/yr}$  (Table 3). The short-term rate comparison between the two studies reveals a dramatic difference. The average rate jumped from  $-4\text{m/yr}$  (1869-1989) to  $-15.8\text{m/yr}$  (1869-1996) for an average rate increase of  $-11.7\text{m/yr}$  (Table 3).

Grand Gosier and Curlew Islands experienced no measurable change in the average long-term gulf shoreline rate comparisons between the two studies; remaining at  $-16.2\text{m/yr}$  (Table 3). The short-term rate comparisons for Grand Gosier and Curlew Islands were dramatically different. McBride and others (1992) documented a rate of  $-23.9\text{m/yr}$  compared to the updated short-term average rate calculation of  $-0.7\text{m/yr}$  (Table 3). The variation in the average short-term shoreline change rates between the two studies indicate a reduction of gulfside erosion by  $23.2\text{m/yr}$

Overall, the South Chandeleur Island showed a modest distinction in the calculated long-term change rates of the two studies. McBride and others (1992) assessed a long-term rate of  $-11.6\text{m/yr}$  (Table 3). This rate is only  $1.3\text{m/yr}$  lower than the rate of  $-12.9\text{m/yr}$  (Table 3) calculated by this study. A rate comparison of the two studies demonstrates a highly dynamic gulf shoreline associated with the short-term life of the South Chandeleur Islands. McBride and others (1992) identified the rate as  $-19.7\text{m/yr}$  (Table 3). The new short-term rate of  $-5.6\text{m/yr}$  (Table 3) shows a  $14.1\text{m/yr}$  reduction in gulfside erosion.

## **BAYSIDE SHORELINE CHANGES**

In terms of the long-term bayside shoreline change history for the 127-year period between 1869 and 1996, Breton Island's shoreline transects measured between 1200m and  $-272\text{m}$  (Table 2, 1869-1996, transects 1-12). The average change was determined to be  $636.0\text{m}$  or  $5.0\text{m/yr}$  (Table 4). Grand Gosier Island was not mapped in 1869, therefore, long-term bay shoreline change measurements did not apply. Curlew Island experienced shoreline change readings between 2432m and 1287m (Table 2, 1869-1996, Transects 17- 53) for an average change of  $1787.2\text{m}$  or  $14.1\text{m/yr}$  (Table 4). The cumulative long-term bay shoreline change for the South Chandeleur Islands ranged between 2432m and  $-272\text{m}$  (Table 2, 1869-1996). The average landward migration was determined to be  $1403.5\text{m}$  at a rate of  $11.1\text{m/yr}$  (Table 4).<sup>6</sup> For the 7.9 years between 1989 and 1996, Breton Island's bay shoreline remained relatively stable compared to its long-term movement. Transect measurements during this period ranged from 316m and  $-81\text{m}$  (Table 2, 1989-1996, transects 1-12). The average change was calculated to be  $16\text{m}$  or  $2.0\text{m/yr}$  (Table 4). Like the stability of Breton Island's bay shoreline during this short-term period, Grand Gosier and Curlew Island's shoreline migration was relatively small when compared to its long-term analysis. Shoreline transect measurements were between 183m and  $-194\text{m}$  (Table 2, 1989-1996, transects 17-53) for an average of  $-22.6\text{m}$  at a rate of  $-2.9\text{m/yr}$  (Table 4). Along the entire bay shoreline of the South Chandeleur Islands, short-term changes were measured between 316m and  $-194\text{m}$  (Table 2, 1989-1996). The overall average change was  $-10.3\text{m}$  at a yearly rate of  $-1.3\text{m/yr}$  (Table 4), which shows a directional shift compared to the long-term shoreline movement.

In the earlier study by McBride and others (1992), long-term and short-term bay shoreline change rates were calculated from years 1869 to 1989 (120 years) and 1978 to 1989 (11 years) respectively. The long-term change rate for Breton Island was reported as 3.9m/yr (Table 4). The short-term rate was found to be -1.2m/yr (Table 4). A comparison of the two long-term rate calculations for Breton Island shows a change from 3.9m/yr (1869-1989) to 5.0m/yr (1869-1996), which denotes an increase of landward migration of 1.1m/yr. The short-term rate comparison between the two studies for Breton Island reveals a change of direction in the bay shoreline movement. A change from 1.2m/yr (1978-1989) to 2.0m/yr (1989-1996) demonstrates migrational shift of 3.2m/yr landward (Table 4).

For Grand Gosier and Curlew Islands, McBride and others (1992) documented the long-term and short-term change rates of 15.0m/yr and 26.8m/yr, respectively (Table 4). Compared to this current study, the long-term change rates remain nearly the same, changing only 0.9m/yr, from 15.0m/yr (1969-1989) to 14.1m/yr (1869-1996) (Table 4). The short-term rate comparison exhibits a far greater disparity. Changing from 26.8m/yr (1978-1989) to -2.9m/yr (1989-1996) the short-term bay shoreline rate shifted 29.7m/yr toward the gulf (Table 4).

The collective rate comparison of the South Chandeleur islands maintains the trends set up by the movement of the separate island groups. The overall long-term rate changed from 10.7m/yr (1869-1989) to 11.1m/yr (1869-1996) demonstrating a negligible difference of 0.4m/yr (Table 4). The short-term rate comparison observes a change from 19.8m/yr (1978-1989) to -1.3m/yr (1989-1996) indicating an adjustment in bay shoreline movement of -21.1m/yr (Table 4).

## **AREA CHANGES**

Area changes for the South Chandeleur Islands have been dramatic since 1869. To maintain compatibility with the McBride and others study (1992), the area changes of two island groups (Breton Island, Grand Gosier and Curlew Island) were analyzed. In addition to the separate analysis of the two island groups, the South Chandeleur barrier islands' area was studied as a whole.

Between the years 1869 and 1996, Breton Island's area changed from 820 acres to 213 acres (Table 5). The average rate of area change fluctuated between 13.3 acres/yr. and 5.4 acres/yr., which indicate reversing periods between land loss and land gain in response to the breaching and healing process along the central island portion (McBride and others, 1992). Examining the long-term change between 1869 and 1996, Breton Island lost 74% of its total area at a rate of -4.8 acres/yr. (Table 6). This long-term rate of loss, acting on the island's area in 1996, forecasts a disappearance date of 2040 (Table 6). This is 53 years less than the disappearance date predicted by the McBride and others (1992) long-term study, which predicted a disappearance date of 2093 using a -3.9 acres/yr. rate of area change (Table 6). For the short-term area loss analysis between the years 1989 and 1996, Breton Island's area decreased from 405 acres to 213 acres (Table 5). This represents a 47% loss at a rate of -24.3 acres/yr. (Table 6). This dramatic short-term loss

rate predicts the disappearance of Breton Island by 2005 (Table 6). Previously, in McBride and others (1992), Breton Island was growing in area at a rate of 5.2 acres/yr. (Table 6). Between 1978 and 1989, the island may have been in a state of recovery from the impact of Hurricane Camille (1969) and, therefore, no disappearance date could be calculated (Table 6).

Like Breton Island, Grand Gosier and Curlew Island's long term analysis to the north also witnessed remarkable fluctuations in area. Between 1869 and 1996, the islands' total area decreased 61%, changing from 1119 acres to 434 acres (Table 5). For the Grand Gosier and Curlew islands, the long-term loss rate of  $-5.4$  acres/yr., acting on the area in 1996, forecasts a disappearance date of 2076 (Table 6). Interestingly, McBride and others (1992) calculated a long-term area loss rate of  $-0.6$  acres/yr. between 1869 and 1989, forecasting a disappearance date of 2103 (Table 6). Despite the decreased loss rate calculated between 1869 and 1996 ( $-5.4$  acres/yr.), the islands' life will be shortened by 27 years, compared to the McBride and others (1992) study, because the islands total area in 1996 was 37% less than it was in 1989 (Table 5). In the short-term area loss analysis for Grand Gosier and Curlew islands, the total area decreased from 684 acres in 1989 to 434 acres in 1996 (Table 5). This demonstrates a 37% loss in area at a rate of  $-31.6$  acres/yr. and forecasts a disappearance date of 2010 (Table 6). No disappearance date could be calculated in the previous study (McBride and others, 1992) because the islands were possibly in a recovery mode from Hurricane Camille, with area increasing at a rate of 25.8 acres/yr. (Table 6).

As expected, the individual trends set up by Breton Island and Grand Gosier and Curlew Islands' area changes remain the same when the South Chandeleur barrier system is studied as a whole. The overall long-term area loss rate between 1869 and 1996 was found to be  $-10.2$  acres/yr. (Table 6). Acting on a total area of 647 acres, in 1996, the new long-term loss rate projects a disappearance date of 2059 (Table 6). This represents a reduction in the life span of the South Chandeleur Islands by 40 years compared to the previous analysis, which predicted a disappearance date of 2099 (Table 6). The short-term area loss rate of  $-56.0$  acres/yr. between the years 1989 and 1996, forecasts a disappearance date of 2008 (Table 6). This demonstrates a complete shift in short-term area change rates calculated by McBride and others (1992). Between 1978 and 1989, a short-term change rate of 31.0 acres/yr. (Table 6) allowed the South Chandeleur Islands' area to rebound after the devastating impact of Hurricane Camille.

## **ACKNOWLEDGEMENTS**

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## **DISCLAIMER**

This poster is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards (and stratigraphic nomenclature). Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

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## FIGURES

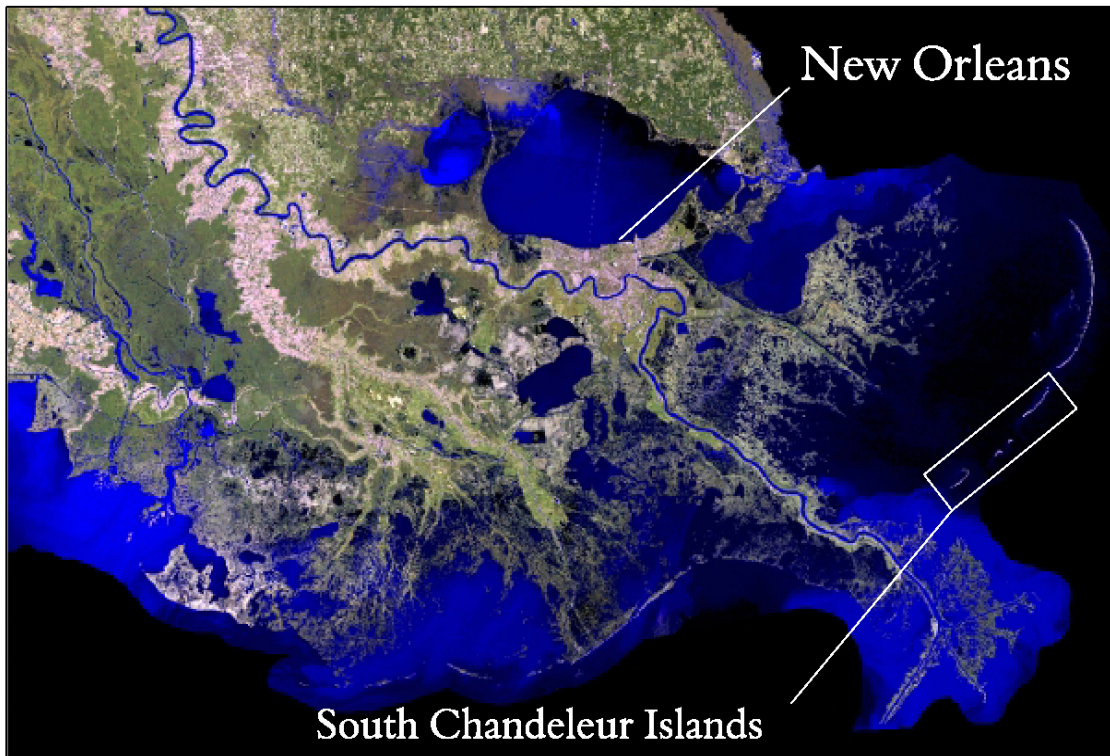
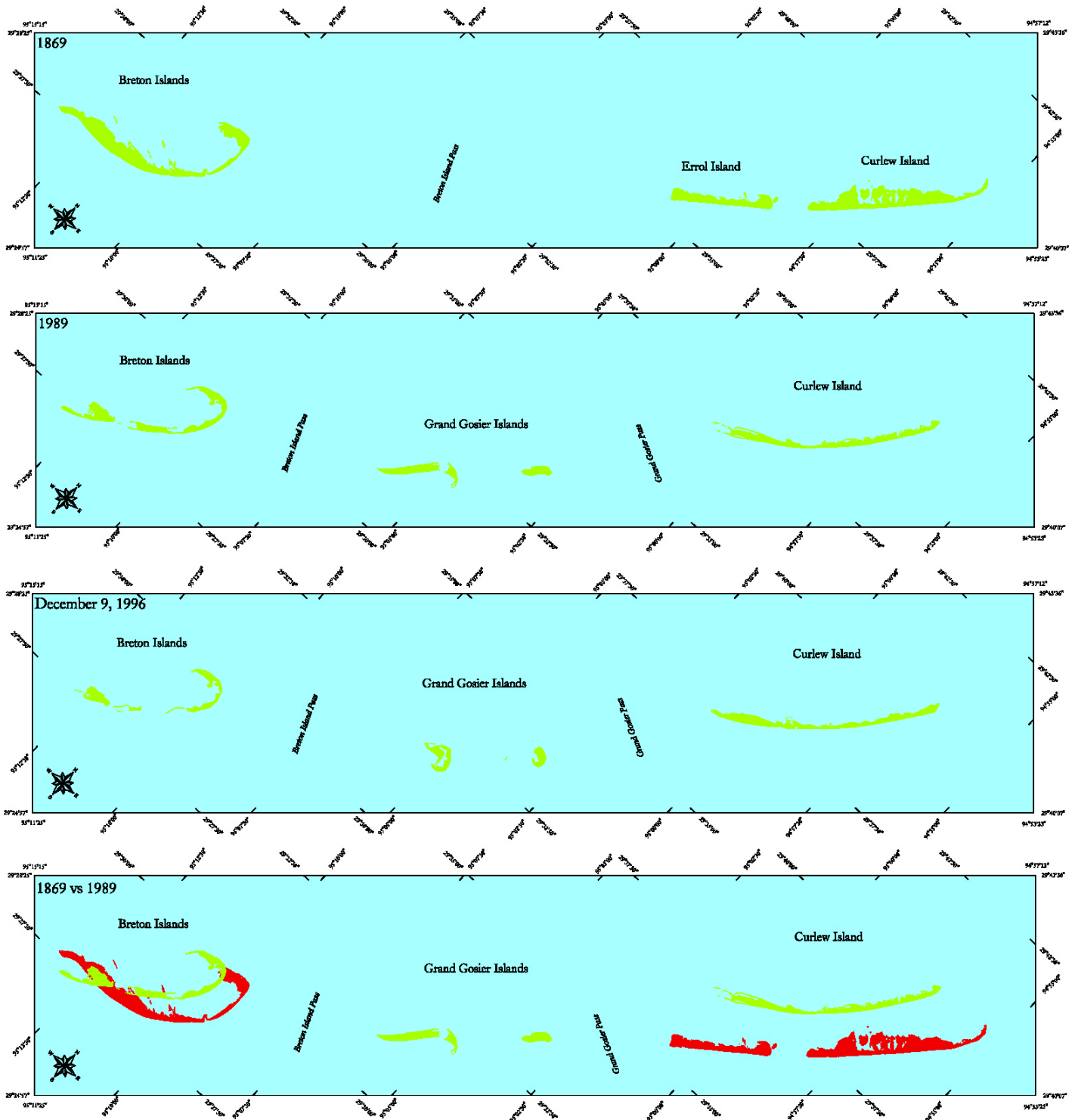
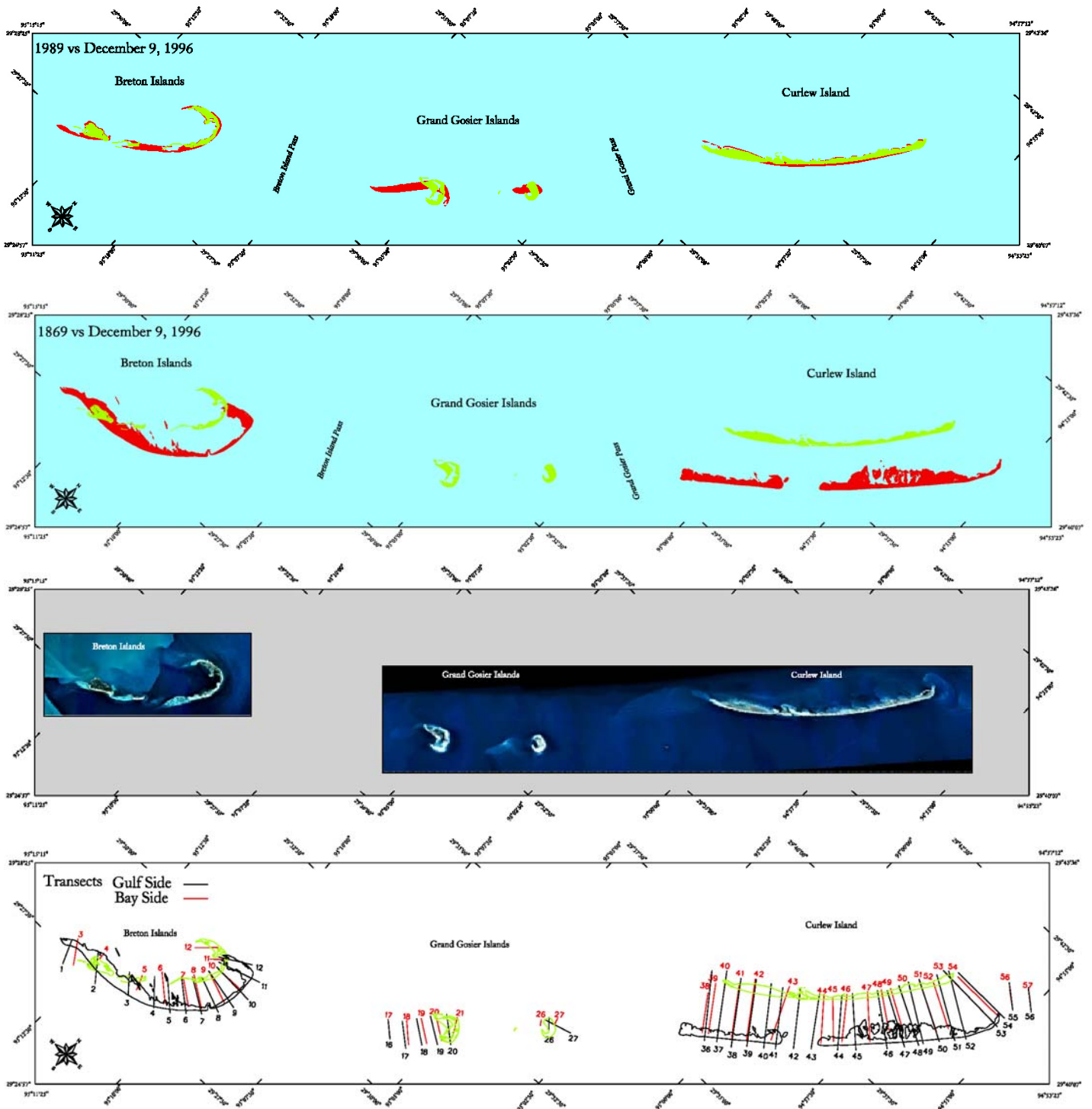


Figure 1. The South Chandeleur islands are located 100km southeast of New Orleans.

# MAPS







TABLES

**Table 1**

| South Chandeleur Islands gulfside magnitude of change (meters) |             |             |
|--|-------------|-------------|
| 1869 - 1989  | 1989 - 1996 | 1869 - 1996 |
| 1  | 702         | 1 na        |
| 2  | 123         | 2 20        |
| 3  | na          | 3 -778      |
| 4  | -590        | 4 na        |
| 5  | -912        | 5 na        |
| 6  | -948        | 6 -1297     |
| 7  | -1042       | 7 -1208     |
| 8  | -1103       | 8 -1178     |
| 9  | -1085       | 9 -1100     |
| 10   | -1046       | 10 -1082    |
| 11   | -1083       | 11 -1171    |
| 12   | -579        | 12 -662     |
| 13   | na          | 13 na       |
| 14   | na          | 14 na       |
| 15   | na          | 15 na       |
| 16   | na          | 16 na       |
| 17   | na          | 17 na       |
| 18   | na          | 18 na       |
| 19   | na          | 19 na       |
| 20   | na          | 20 na       |
| 21   | na          | 21 na       |
| 22   | na          | 22 na       |
| 23   | na          | 23 na       |
| 24   | na          | 24 na       |
| 25   | na          | 25 na       |
| 26   | na          | 26 na       |
| 27   | na          | 27 na       |
| 28   | na          | 28 na       |
| 29   | na          | 29 na       |
| 30   | na          | 30 na       |
| 31   | na          | 31 na       |
| 32   | na          | 32 na       |
| 33   | na          | 33 na       |
| 34   | na          | 34 na       |
| 35   | na          | 35 na       |
| 36   | na          | 36 na       |
| 37   | na          | 37 -2226    |
| 38   | -2084       | 38 -2027    |
| 39   | -1961       | 39 -1922    |
| 40   | -1916       | 40 -1892    |
| 41   | -1884       | 41 -1894    |
| 42   | na          | 42 na       |

**Table 2**

| South Chandeleur Islands bayside magnitude of change (meters) |             |             |
|---|-------------|-------------|
| 1869 - 1989   | 1989 - 1996 | 1869 - 1996 |
| 1   | na          | 1 na        |
| 2   | na          | 2 na        |
| 3   | -922        | 3 na        |
| 4   | -226        | 4 -272      |
| 5   | 280         | 5 -81       |
| 6   | 793         | 6 na        |
| 7   | 805         | 7 316       |
| 8   | 1170        | 8 -24       |
| 9   | 1202        | 9 -2        |
| 10  | 1106        | 10 -7       |
| 11  | -33         | 11 -11      |
| 12  | na          | 12 -17      |
| 13  | na          | 13 na       |
| 14  | na          | 14 na       |
| 15  | na          | 15 na       |
| 16  | na          | 16 na       |
| 17  | na          | 17 na       |
| 18  | na          | 18 na       |
| 19  | na          | 19 na       |
| 20  | na          | 20 7        |
| 21  | na          | 21 30       |
| 22  | na          | 22 na       |
| 23  | na          | 23 na       |
| 24  | na          | 24 na       |
| 25  | na          | 25 na       |
| 26  | na          | 26 na       |
| 27  | na          | 27 -116     |
| 28  | na          | 28 na       |
| 29  | na          | 29 na       |
| 30  | na          | 30 na       |
| 31  | na          | 31 na       |
| 32  | na          | 32 na       |
| 33  | na          | 33 na       |
| 34  | na          | 34 na       |
| 35  | na          | 35 na       |
| 36  | na          | 36 na       |
| 37  | na          | 37 na       |
| 38  | na          | 38 na       |
| 39  | na          | 39 na       |
| 40  | 2222        | 40 -194     |
| 41  | 1848        | 41 -164     |
| 42  | 2150        | 42 -68      |

|    |       |    |      |    |       |    |      |    |     |    |      |
|----|-------|----|------|----|-------|----|------|----|-----|----|------|
| 43 | na    | 43 | -113 | 43 | na    | 43 | 1539 | 43 | -9  | 43 | 1531 |
| 44 | -1751 | 44 | -89  | 44 | -1843 | 44 | 1537 | 44 | 183 | 44 | 1718 |
| 45 | -733  | 45 | -83  | 45 | -1844 | 45 | 1527 | 45 | 37  | 45 | 1562 |
| 46 | -1814 | 46 | -90  | 46 | -1902 | 46 | 1676 | 46 | -16 | 46 | 1659 |
| 47 | -1906 | 47 | -78  | 47 | -1985 | 47 | 1857 | 47 | -9  | 47 | 1845 |
| 48 | -1981 | 48 | -67  | 48 | -2055 | 48 | 1328 | 48 | -39 | 48 | 1287 |
| 49 | -1995 | 49 | -54  | 49 | -2052 | 49 | 1497 | 49 | -23 | 49 | 1472 |
| 50 | -2094 | 50 | -47  | 50 | -2141 | 50 | 1657 | 50 | 54  | 50 | 1712 |
| 51 | -2223 | 51 | 13   | 51 | -2209 | 51 | 1916 | 51 | -8  | 51 | 1913 |
| 52 | -2381 | 52 | 32   | 52 | -2350 | 52 | 1811 | 52 | 26  | 52 | 1839 |
| 53 | -2533 | 53 | 18   | 53 | -2519 | 53 | 2712 | 53 | -76 | 53 | 2432 |
| 54 | na    | 54 | na   | 54 | na    | 54 | na   | 54 | na  | 54 | na   |
| 55 | na    | 55 | na   | 55 | na    | 55 | na   | 55 | na  | 55 | na   |
| 56 | na    | 56 | na   | 56 | na    | 56 | na   | 56 | na  | 56 | na   |
| 57 | na    | 57 | na   | 57 | na    | 57 | na   | 57 | na  | 57 | na   |
| 58 | na    | 58 | na   | 58 | na    | 58 | na   | 58 | na  | 58 | na   |
| 59 | na    | 59 | na   | 59 | na    | 59 | na   | 59 | na  | 59 | na   |
| 60 | na    | 60 | na   | 60 | na    | 60 | na   | 60 | na  | 60 | na   |

**Table 3: Average Gulfside Erosion Rates for the South Chandeleur Islands: 1869 - 1996**

| Years                          | Average Gulfside Erosion Rates (m/yr) |                              | South Chandeleur Island Arc |
|--------------------------------|---------------------------------------|------------------------------|-----------------------------|
|                                | Breton Island                         | Grand Gosier, Curlew Islands |                             |
| Previous Analysis <sup>1</sup> | -4.1                                  | -23.9                        | -19.7                       |
| 1978 - 1989 (short-term)       |                                       |                              |                             |
| 1869 - 1988 (long-term)        | -5.7                                  | -16.2                        | -11.6                       |
| New Analysis <sup>2</sup>      | -15.8                                 | -0.7                         | -5.6                        |
| 1989 - 1996 (short-term)       |                                       |                              |                             |
| 1869 - 1996 (long-term)        |                                       |                              |                             |

<sup>1</sup> McBride and others (1992)

<sup>2</sup> This USGS Open-File Report

**Table 4: Average Bayside Erosion Rates for the South Chandeleur Islands: 1869 - 1996**

| Years                          | Average Bayside Erosion Rates (m/yr) |                              |                          |
|--------------------------------|--------------------------------------|------------------------------|--------------------------|
|                                | Breton Island                        | Grand Gosier, Curlew Islands | South Chandeleur Islands |
| Previous Analysis <sup>1</sup> | -1.2                                 | 26.8                         | 19.8                     |
| 1978 - 1989 (short-term)       |                                      |                              |                          |
| 1869 - 1988 (long-term)        | -3.9                                 | 15.0                         | 10.7                     |
| New Analysis <sup>2</sup>      | 2.0                                  | -2.9                         | -1.3                     |
| 1989 - 1996 (short-term)       |                                      |                              |                          |
| 1869 - 1996 (long-term)        | 5.0                                  | 14.1                         | 11.1                     |

<sup>1</sup> McBride and others (1992)

<sup>2</sup> This USGS Open-File Report

**Table 5: The South Chandeleur Islands Area Measurements by Island (acres)**

|                                | Previous <sup>1</sup> |      |      | Update <sup>2</sup> |
|--------------------------------|-----------------------|------|------|---------------------|
|                                | 1869                  | 1978 | 1989 | Dec 1996            |
| Breton Island                  | 820                   | 348  | 405  | 213                 |
| Grand Gosier, Curlew Islands   | 1119                  | 400  | 684  | 434                 |
| South Chandeleur Island Totals | 1939                  | 748  | 1089 | 647                 |

<sup>1</sup> McBride and others (1992)

<sup>2</sup> This USGS Open-File Report

**Table 6: South Chandeleur Islands Area Change Rate and Predicted Disappearance Dates: 1869 – 1996<sup>1</sup>**

|                                  | Long-Term Rate                    |                 | Short-Term Rate                   |                 | Previous Long-Term DD <sup>5</sup> | Previous Short-Term DD <sup>6</sup> | New Long-Term DD <sup>3</sup> | New Short-Term DD <sup>4</sup> |
|----------------------------------|-----------------------------------|-----------------|-----------------------------------|-----------------|------------------------------------|-------------------------------------|-------------------------------|--------------------------------|
|                                  | Previous 1869 - 1989 <sup>2</sup> | New 1869 - 1996 | Previous 1978 - 1989 <sup>2</sup> | New 1989 - 1996 |                                    |                                     |                               |                                |
| Breton Island                    | -3.9                              | -4.8            | 5.2                               | -24.3           | 2093                               | n.a. <sup>7</sup>                   | 2040                          | 2005                           |
| Grand Gosier, Curlew Islands     | -6.0                              | -5.4            | 25.8                              | -31.6           | 2103.0                             | n.a. <sup>7</sup>                   | 2076.0                        | 2010.0                         |
| South Chandeleur Islands (total) | -9.9                              | -10.2           | 31.0                              | -56.0           | 2099.0                             | n.a. <sup>7</sup>                   | 2059.0                        | 2008.0                         |

<sup>1</sup> Area Change Rate in acres per year (a/y)

<sup>2</sup> Data Converted from hectares to acres from McBride and others (1992)

<sup>3</sup> New long-term disappearance date: 1869 - 1996 [127 yrs]

<sup>4</sup> New short-term area change date: 1989 - 1996 [7.9 yrs]

<sup>5</sup> Previous long-term disappearance date: 1869 - 1989 (McBride and others, 1992)

<sup>6</sup> Previous short-term disappearance date: 1978 - 1989 (McBride and others, 1992)

<sup>7</sup> Not Applicable because of increase in area