SHORELINE CHANGES IN THE SOUTH CHANDELEUR ISLANDS BARRIER ARC: 1869 - 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 (Williams and others, 1992; Sallenger and Williams 1992; Paxton and others, 1993). Building on the USGS Louisiana Barrier Island Study (Williams and others, 1992), this USGS Open-File Report depicts shoreline changes between 1887 and 1996, which provides an 8.5-year update of McBride and others (1992).

The Timbalier Islands are located about 100 km south-southwest of New Orleans (Figure 1). This barrier island shoreline is 50 km long and extends east from Cat Island Pass to Raccoon Pass. The Timbalier Islands represent a flooding barrier island system developed from the transgressive reworking of a abandoned distributary of the Lafourche delta complex within the Mississippi River delta plain (Penland and others, 1992). Island evolution is dominated by sediment longshore transport and storm overwash, causing the island arc to migrate to the north and west. The present configuration of the Timbalier Island consists of Timbalier Island to the west, Timbalier Shoal, and East Timbalier Island to the east. Timbalier Shoal, located between the two islands within Little Pass Timbalier, is a transient area of moving sand, which is subducted by periods of transgression. The Gulf shoreline of East Timbalier Island has been armored by a rock seawall with a second seawall constructed landward in an attempt to protect oil and gas facilities on the bayside.

In order to quantify shoreline changes since January 21, 1998, new vertical aerial mapping photography was acquired on December 9, 1996. The methods and measures used by McBride and others (1992) were used to insure data compatibility of the new measurements and analysis (Plate 5). Table 1 presents the transect measurements of shoreline change for the Timbalier 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 progradation and a positive sign signifies a landward movement or erosion.

Island evolution is predominately driven by longshore sediment transport and storm overwash, causing the island arc to migrate to the north and west while slowly losing land area. Storm overwash predominates along East Timbalier and Timbalier Shoal, while longshore transport dominates at Timbalier Island. The highest rates of erosion occur on the eastern ends of each island and lesser along the Gulf shoreline toward the west. The bayside of the islands experiences edge erosion along the entire length of the Timbalier Bay to the north. For long-term comparisons, new change data is more meaningful than lateral shoreline retreat along the Timbalier Islands because of the high rate of land migration. Island arc has been significantly reduced by periodic storm fronts which killed extensive areas of black mangrove swamp, and hurricanes which significantly altered the landscape in a short amount of time.

Between 1887 and 1996, shoreline change was dynamic along the entire length of the Timbalier barrier island arc (Plate 5). The land areas shifted by island migration so that many transects yielded contradictory data. The west end of Timbalier Island experienced land accretion between 1887 and 1964 by longshore sediment transport and spit formation at the east and accretion of 9132 m. Timbalier Island came into existence on the geologic record at the west end of East Timbalier Island breached sometime between 1996 and 1978 and migrated further to the west.

GULFSIDE SHORELINE CHANGES

In terms of long-term, gulfside shoreline change history for the 109 year period between 1887 and 1996 (Table 1; Plate 6), the entire Timbalier barrier island arc has generally changed land areas between +998 m at the prograding west end of Timbalier Island and -2057 m at the east end of East Timbalier Island. This was an average change of -1050.4 m at an average rate of -9.9 mp-1 for the Timbalier barrier island arc duration. Timbalier Island experienced shoreline changes between +798 m and -1132 m with an average change of -167.9 m along the Gulf shoreline, for an average rate of change of -1.4 mp-1. The highest rate of shoreline erosion occurred where East Timbalier Island migrated to the northeast. The erosion at East Timbalier Island was measured between -1657 m and -2057 m with the maximum rate of land loss measurement of -2229.1 m. The average annual rate of change for this 109 year period for East Timbalier Island was -18.1 mp-1.

In terms of short-term shoreline change for the 8.9 year period between 1988 and 1996 (Table 1; Plate 5), the island arc experienced less westward migration and more edge erosion, probably due to the severe hurricane impact sustained in 1995. The measurement of gulfside shoreline change along the Timbalier Barrier Island arc ranged between +160 m at the western end of Timbalier Island to -458 m at the east end of Timbalier Island with an average change of -95.9 m at an average rate of -10.3 m. Although Timbalier Island measured both accretion, East Timbalier Island experienced higher continuous gulfside shoreline erosion. East Timbalier Island measurements were all negative and showed the shoreline was shortened by both seaward and -442 m where the seaward filled and the shoreline retreated in the near-rock seawall. Timbalier Island had an average shoreline change measurement of -42.6 m with an average rate of shoreline change of -4.5 mp-1. East Timbalier Island had an average shoreline change measurement of -122.9 m for an average rate of shoreline change of -17.2 mp-1.

Previous work by McBride and others (1992) for the Timbalier barrier island arc documented a long-term (1887-1992) gulfside change rate of -12.2 mp-1 and a short-term (1978-1992) gulfside change rate of -14.5 mp-1 (Table 2). Between 1887 and 1992, the average rate of gulfside shoreline change for the Timbalier barrier island arc was -9.9 mp-1. Comparing 1988 and 1996 for the new short-term gulfside change rate, the average of gulfside shoreline change for Timbalier Island was +10.4 m and -42.6 m with an average of -9.9 m with the new short-term gulfside change rate of -10.3 mp-1. Although the rate of erosion is still high, our new analysis indicates that the long-term rate of erosion has decelerated by 2.3 mp-1 since 1992.

BAYSIDE SHORELINE CHANGES

In terms of long-term shoreline change history for the 109 year period between 1887 and 1996, the measurement of bayside shoreline change is different in analysis along the entire length of the Timbalier barrier island arc because of the transmission lateral migration of the islands. The changes ranged between +2923 m at the prograding east end of East Timbalier Island and -1402 m at the west end of Timbalier Island where a large area of mangroves was lost during a freeze. The average shoreline change for the Timbalier barrier island arc shoreline was +938.8 m at an average rate of -8.6 mp-1 for the 109 year period. For the small area that could be compared statistically at Timbalier Island, the bayside shoreline change measured between -187 m and -1402 m with an average change of -866.4 m. The average long-term average rate of change at Timbalier Island was -7.6 mp-1. The bayside shoreline changes at East Timbalier Island was measured between +1259 m and +2923 m with the maximum rate of land loss measurement +2229.1 m as a result of landward lateral migration. The average annual bayside rate of change for this 109 year period for East Timbalier Island was +21.4 mp-1.

In terms of short-term shoreline change for the 8.9 year period between 1988 and 1996, the island arc experienced less migration and more edge erosion along the bayside shoreline, probably due to the severe hurricane impact sustained in 1995 and the rock seawall along East Timbalier Island. The measurement of bayside shoreline change along the Timbalier barrier island arc ranged between +437 m at Timbalier Island to -216 m at the center of Timbalier Island with an average of +18.8 m at an average rate of 2.2 mp-1. The bayside shoreline change at Timbalier Island ranged between +364 m at the east spit migrated landward and -314 m in the center of the island, with an average bayside shoreline change measurement of -24.2 m. The average rate of bayside shoreline change at Timbalier Island was -4.6 mp-1. East Timbalier Island bayside shoreline change measurements ranged between +971 m at the west end and -174 m. East Timbalier Island had an average bayside shoreline change measurement of -49.3 m with an average rate of shoreline change of -5.1 mp-1.

Previous work by McBride and others (1992) for the Timbalier Islands documented a long-term (1887-1992) bayside change rate of +11.7 mp-1 and a short-term (1978-1992) bayside change rate of -7.9 mp-1 (Table 2). Between 1887 and 1992 for the new long-term arc, the average rate of bayside shoreline change for the Timbalier barrier island arc was +8.7 mp-1. Comparing 1988 and 1996, the new short-term bayside change rate was -8.2 mp-1. Our new analysis indicates that the long-term landward migration has given way to short-term shoreline edge erosion. The long-term bayside shoreline change rate for the Timbalier barrier island arc has decelerated from +11.7 mp-1 (1887-1992) to +8.7 mp-1 (1887-1996) which indicates an over all slowing of landward migration. The short-term bayside shoreline change rate has increased from -7.9 mp-1 (1978 - 1992) to -8.2 mp-1 (1988-1996) which indicates an increase in bayside erosion.

AREA CHANGES

Area changes of the Timbalier barrier island arc have been dramatic since 1887. Between 1887 and 1996, the Timbalier barrier island arc decreased from 4143 acres to 1442 acres at a rate of -24.5 acres per year (pa-1) (Table 4). If this long-term rate of area loss continued, the island arc would be consumed in 2058, it forecasts a disappearance date of 2054. Previously in McBride and others (1992), the Timbalier island barrier arc decreased in area at a rate of -22.8 pa-1 between 1887 and 1992, suggesting the long-term data of disappearance based on the 1992 island area would be 2074 (Table 5). The small increase in the long-term rate of land loss was calculated to shorten the life of the Timbalier barrier island arc by 22 years. The previous short-term rate of area loss for the Timbalier barrier island arc between 1978 and 1992 was -72.7 pa-1, probably due to the loss of area measures by storm fronts and heavy hurricane and winter storm impacts. Between 1988 and 1996, the rate of land loss was still high but had slowed to -54.1 pa-1. The predicted disappearance date forecast by these rates changed from 1999 to 2022, increasing the life of the barrier islands by 23 years.

At the long-term rate of -22.8 mp-1, 1.28 of the 1992 landscape was expected to disappear per year. At short-term rate of -72.7 mp-1, 4.08 of the 1992 landscape was being lost per year, and at -54.1 mp-1, 3.04 of the 1996 landscape was being lost per year.

Between 1887 and 1996, Timbalier Island decreased from 3407 acres to 1114 acres at a rate of -22.4 ap-1 (Table 4). The long-term rate of area loss acting on the area of Timbalier Island in 1996 forecasts a disappearance date of 2044. Previously in McBride and others (1992), Timbalier Island decreased in area at a rate of -22.3 ap-1 between 1887 and 1992, suggesting the long-term date of disappearance would be 2044 (Table 5). The very small decrease in the long-term rate of land loss was calculated to lengthen the life of Timbalier Island by 2 years. The previous short-term rate of area loss for Timbalier Island in 1992 between 1978 and 1992 was -112.9 ap-1, and had a predicted disappearance date of 2000. This high rate of land loss was probably due to heavy hurricane and winter storm impacts, a loss of area that killed the black mangrove swamp, and partly due to the direct removal of area by the construction of canals. Between 1988 and 1996, the rate of land loss slowed to -54.1 ap-1. The predicted disappearance date for East Timbalier Island calculated by the new area changed from 2000 to 2040, increasing the life of Timbalier Island by 40 years.

East Timbalier Island increased in area from 1887 until approximately 1978 when it began to experience a cumulative land loss. Previously in McBride and others (1992), the East Timbalier Island increased in area at a long-term area change rate of +1.8 ap-1 between 1887 and 1992, and forecasted the predicted date of disappearance (Table 5). Between 1887 and 1996, East Timbalier Island experienced a cumulative decrease in area from 477 acres to 300 acres at a rate of -1.4 ap-1 (Table 4). This long-term rate of area loss forecasted a disappearance date of 2164. The previous short-term rate of area loss for East Timbalier Island between 1978 and 1992 was -23.2 ap-1, probably due to heavy hurricane and winter storm impacts and partly due to the direct removal of area by the construction of canals. Between 1988 and 1996, the short-term rate of land loss slowed to -18.1 ap-1. The predicted disappearance date for East Timbalier Island calculated by the new area changed from 1997 to 2006.

SUMMARY

The Timbalier barrier island arc has historically exhibited high rates of lateral and landward migration with varying rates of area loss. Longshore sediment transport and storm-induced overwash has kept the islands moving but generally healthy, up until the last few decades. The previous short-term data for 1978 to 1988 documented exceptionally high landform rates that have since slowed for the short-term data documented for 1988 to 1996. The new short-term rates of land loss are still close to double the long-term average.

A comparison of the previous and new long-term shoreline change rates for the Timbalier barrier island arc show that the general trend of island migration has slowed, while the loss of land area has increased. The gulfside shoreline is not eroding as rapidly and the bayside is not prograding as quickly as previous data indicated, with a increase in land loss.

For short-term changes, the short-term gulfside shoreline erosion rates of 1988-1996 have slowed since the erosion rates documented during 1978-1988, while the bayside short-term erosion rates have increased.

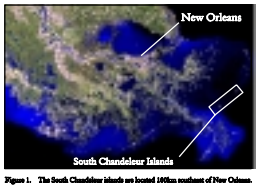

Figure 1. The South Chandeleur islands are located 100km southeast of New Orleans.

Table 1

South Chandeleur Islands gulfside magnitude of change (meters)					
1869-1989		1989-1996		1869-1996	
1	798	1	n.a.	1	n.a.
2	n.a.	2	n.a.	2	n.a.
3	-251	3	-251	3	-251
4	-218	4	-218	4	-218
5	-213	5	n.a.	5	n.a.
6	-1132	6	-251	6	-1007
7	-1132	7	-251	7	-1007
8	-1132	8	-251	8	-1007
9	-1132	9	-251	9	-1007
10	-1132	10	-251	10	-1007
11	-1132	11	-251	11	-1007
12	-1132	12	-251	12	-1007
13	-1132	13	-251	13	-1007
14	n.a.	14	n.a.	14	n.a.
15	n.a.	15	n.a.	15	n.a.
16	n.a.	16	n.a.	16	n.a.
17	n.a.	17	n.a.	17	n.a.
18	n.a.	18	n.a.	18	n.a.
19	n.a.	19	n.a.	19	n.a.
20	n.a.	20	n.a.	20	n.a.
21	n.a.	21	n.a.	21	n.a.
22	n.a.	22	n.a.	22	n.a.
23	n.a.	23	n.a.	23	n.a.
24	n.a.	24	n.a.	24	n.a.
25	n.a.	25	n.a.	25	n.a.
26	n.a.	26	n.a.	26	n.a.
27	n.a.	27	n.a.	27	n.a.
28	n.a.	28	n.a.	28	n.a.
29	n.a.	29	n.a.	29	n.a.
30	n.a.	30	n.a.	30	n.a.
31	n.a.	31	n.a.	31	n.a.
32	n.a.	32	n.a.	32	n.a.
33	n.a.	33	n.a.	33	n.a.
34	n.a.	34	n.a.	34	n.a.
35	n.a.	35	n.a.	35	n.a.
36	n.a.	36	n.a.	36	n.a.
37	n.a.	37	n.a.	37	n.a.
38	n.a.	38	n.a.	38	n.a.
39	n.a.	39	n.a.	39	n.a.
40	n.a.	40	n.a.	40	n.a.
41	n.a.	41	n.a.	41	n.a.
42	n.a.	42	n.a.	42	n.a.
43	n.a.	43	n.a.	43	n.a.
44	n.a.	44	n.a.	44	n.a.
45	n.a.	45	n.a.	45	n.a.
46	n.a.	46	n.a.	46	n.a.
47	n.a.	47	n.a.	47	n.a.
48	n.a.	48	n.a.	48	n.a.
49	n.a.	49	n.a.	49	n.a.
50	n.a.	50	n.a.	50	n.a.

Table 2

South Chandeleur Islands bayside magnitude of change (meters)					
1869-1989		1989-1996		1869-1996	
1	n.a.	1	n.a.	1	n.a.
2	n.a.	2	n.a.	2	n.a.
3	2923	3	n.a.	3	n.a.
4	2923	4	-218	4	2705
5	2923	5	-218	5	2705
6	2923	6	-251	6	2672
7	2923	7	-251	7	2672
8	2923	8	-251	8	2672
9	2923	9	-251	9	2672
10	2923	10	-251	10	2672
11	2923	11	-251	11	2672
12	2923	12	-251	12	2672
13	2923	13	-251	13	2672
14	n.a.	14	n.a.	14	n.a.
15	n.a.	15	n.a.	15	n.a.
16	n.a.	16	n.a.	16	n.a.
17	n.a.	17	n.a.	17	n.a.
18	n.a.	18	n.a.	18	n.a.
19	n.a.	19	n.a.	19	n.a.
20	n.a.	20	n.a.	20	n.a.
21	n.a.	21	n.a.	21	n.a.
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35	n.a.	35	n.a.	35	n.a.
36	n.a.	36	n.a.	36	n.a.
37	n.a.	37	n.a.	37	n.a.
38	n.a.	38	n.a.	38	n.a.
39	n.a.	39	n.a.	39	n.a.
40	n.a.	40	n.a.	40	n.a.
41	n.a.	41	n.a.	41	n.a.
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45	n.a.	45	n.a.	45	n.a.
46	n.a.	46	n.a.	46	n.a.
47	n.a.	47	n.a.	47	n.a.
48	n.a.	48	n.a.	48	n.a.
49	n.a.	49	n.a.	49	n.a.
50	n.a.	50	n.a.	50	n.a.

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

Years	Average Gulfside Erosion Rates		
	Breton Island	Grand Gosier Islands	South Chandeleur Islands
Previous Analysis[1]			
1978 - 1989 (short-term)	-4.1 m^2	-23.9 m^2	-19.7 m^2
1869 - 1989(long-term)	-5.7 m^2	-16.3 m^2	-11.6 m^2
New Analysis[2]			
1989 - 1996 (short-term)	-15.8 m^2	-0.7 m^2	-5.6 m^2
1869 - 1996 (long-term)	-7.4 m^2	-16.3 m^2	-12.9 m^2

[1]McBride and others (1992)
[2]This USGS Open-File Report

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

Years	Average Bayside Erosion Rates		
	Breton Island	Grand Gosier Islands	South Chandeleur Islands
Previous Analysis[1]			
1978 - 1989 (short-term)	-1.3 m^2	26.8 m^2	19.8 m^2
1869 - 1989(long-term)	-3.9 m^2	15.0 m^2	10.7 m^2
New Analysis[2]			
1989 - 1996 (short-term)	2.0 m^2	-2.9 m^2	-1.3 m^2
1869 - 1996 (long-term)	5.0 m^2	14.1 m^2	11.1 m^2

[1]McBride and others (1992)
[2]This USGS Open-File Report

Table 5
The South Chandeleur Islands Area Measurements By Island (acres)

	Previous[1]			Update[2]
	1869	1978	1992	Dec 1996
Breton Island	920	548	495	213
Grand Gosier, Curlew Islands	1119	480	484	434
South Chandeleur Island Totals	1929	748	1089	647

[1]McBride and others (1992)
[2]This USGS Open-File Report

Table 6
South Chandeleur Islands Area Change Rate and Predicted Disappearance Dates: 1869 - 1996[1]

	Long-Term Rate		Short-Term Rate							
	Previous 1869 - 1992	New 1869 - 1996	Previous 1978 - 1992	New 1988 - 1996	Previous Long-Term DD[2]	Previous Short-Term DD[3]	New Long-Term DD[4]	New Short-Term DD[5]
Breton Island	-3.9	-4.6	1.5	-24.3	2092	n.a.[7]	2046	2007
Grand Gosier, Curlew Islands	-6.0	-2.4	21.0	-31.6	2083	n.a.[7]	2074	2010
South Chandeleur Islands (total)	-9.9	-16.2	21.0	-54.0	2099	n.a.[7]	2029	2000

[1]Area Change Rate in acres per year (pa^{-1})
[2]Date Predicted from Bretton to acres from McBride and others (1992)
[3]New long-term area change date: 1869 - 1996 (127 yr)
[4]New short-term area change date: 1989 - 1996 (7.0 yr)
[5]Previous long-term disappearance date 1869 - 1989 (McBride and others, 1992)
[6]Previous short-term disappearance date 1978 - 1989 (McBride and others, 1992)
[7]Not Applicable because of increase in area

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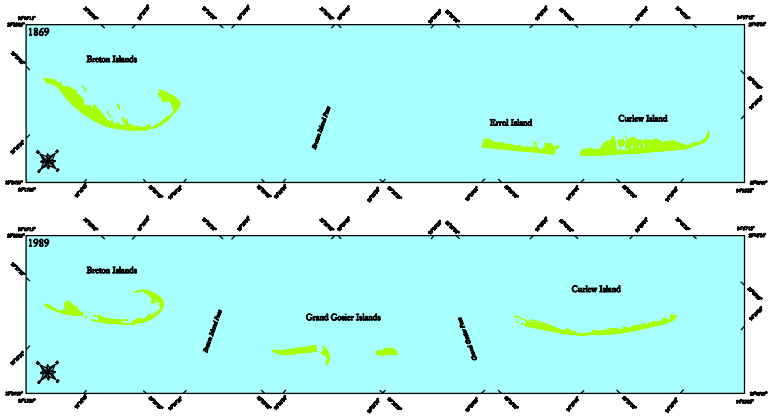

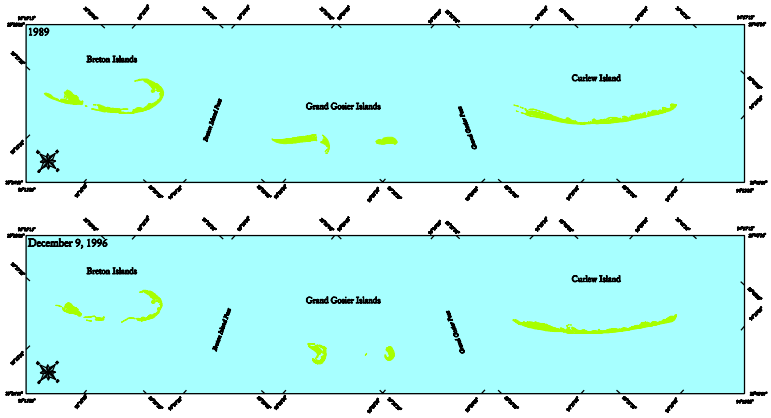

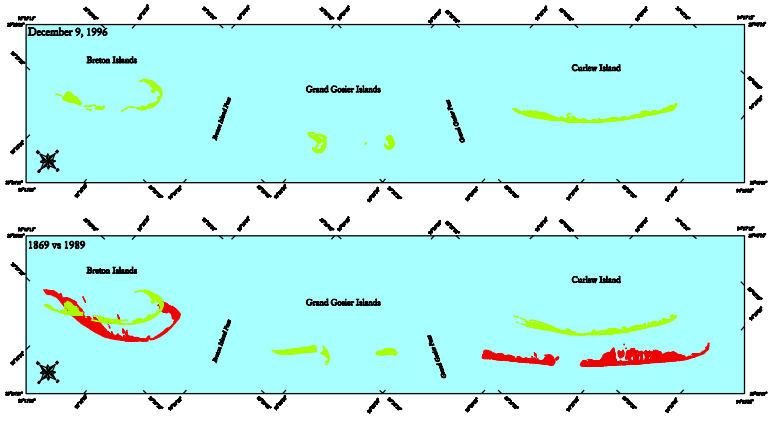

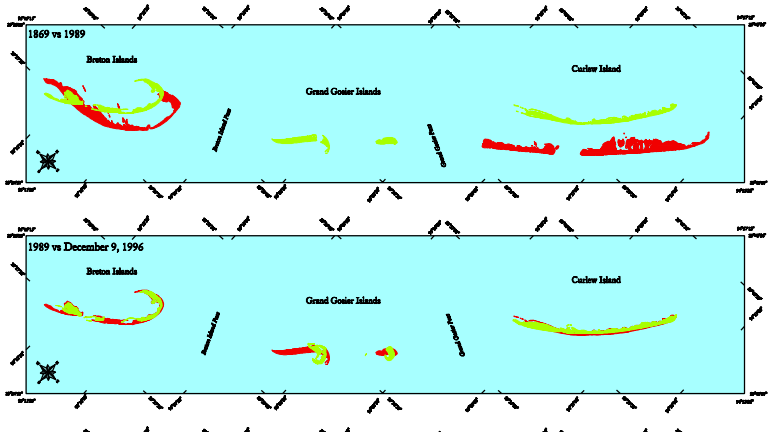

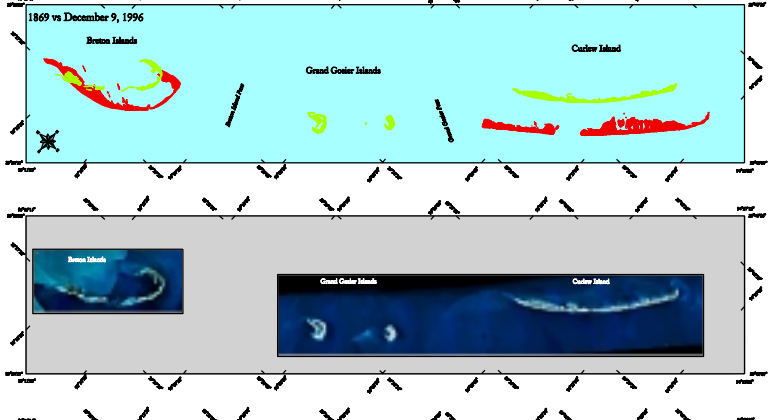

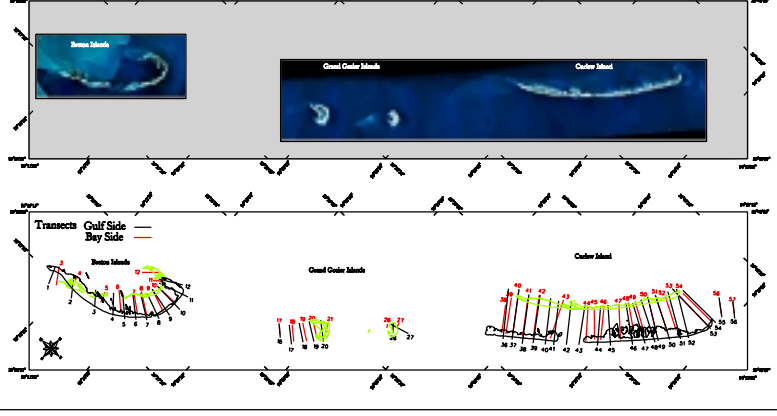

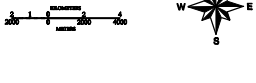

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