Historical Longshore Bar Mapping
Tampa Bay, Florida

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Executive Summary

Photointerpretation and mapping of longshore bars in seagrass meadows in Tampa Bay using historical and current vertical aerial photographs has shown that the visible length of longshore bars as interpreted from circa 1940 black and white vertical aerial photography had declined by 56.8% as compared with similar photointerpretation and mapping done from 2004 true color vertical aerial photography. Total number of bar features initially declined by 26% through 1980, but the most current photointerpretation indicates a recent increase representing more than doubling of such features, though each is generally smaller in length than historical bars.

These results are consistent with the working hypotheses concerning simultaneous loss of seagrass cover and longshore bars over the last 65 years in Tampa Bay, but are not proof of cause and effect. This effort is part of the continued ongoing research as part of the Tampa Bay Longshore Bars Working Group interagency project (see http://www.tbeptech.org/htm/Longshorebars.htm) to further define specific limiting factors on natural seagrass recovery, such as natural and anthropogenic wave energy, that could be ameliorated to assist in seagrass restoration in Tampa Bay.

Introduction

Longshore sand bars are a commonly reported feature in seagrass meadows in Tampa Bay, Florida (Lewis et al. 1985, Lewis and Estevez 1988). These features are theorized to be important in the long term persistence of seagrass meadows in which they are found (Lewis 2002). Seagrass bars appear to have changed and declined over time, but no actual study of their historical and current distribution has been done.

Recent documented improvements to water quality in the bay have increased water transparency through the removal of nutrients and associated micro and macroalgal blooms (Johansson and Lewis 1992; Lewis et al. 1999). However, the most recent seagrass mapping efforts indicate that projected increases in total area of seagrass within the bay have leveled off at around 10,500 ha (26,000 acres)(Tomasko presentation January 14, 2003). The predictions and goals for seagrass recovery from the Tampa Bay Estuary Program target of 15,000 ha (37,000 acres) thus may not be met in a timely manner. The most likely explanation for this stabilized recovery appears to be related, in part, to natural and man-made wave energy (i.e., large boat wakes) impacting seagrass meadows in the bay (Lewis 2002) and this hypothesis has been substantially supported by the research of Fonseca and Bell (1998), Robbins et al (2002) and Fonseca et al. (2002a).

In previous studies, Fonseca et al. (2002b) used a Relative Exposure Index (REI) model to predict the effects of wave influence on seagrass habitat characteristics. Also, Fonseca et al. (2002a) conducted a study in Tampa Bay to evaluate the potential effect of lost sand bars on wave exposure influence and seagrass distribution by deriving relationships between REI and probability of seagrass occurrence. While the REI model provides useful preliminary indications of seagrass wave energy tolerances, the primary limitation of this approach is that it does not present actual magnitudes of wave energy at the surface or the wave induced shear stress at the bottom. Correlation of seagrass cover with actual wave magnitudes, as proposed for later phases of this project, will allow evaluation of the wave forces on plant establishment and growth. This additional information regarding wave energy at the surface and wave induced shear stress at the bottom may provide better correlations with seagrass locations and thus enhance predictions methods for selecting seagrass colony locations. This information could also be used to predict the success of seagrass survival during various stages of plant establishment and for a variety of seagrass planting methods. Correlations can also be made between hydrodynamic forces in the vertical water column and the depth of various parts of the plant body. This could be useful in determining whether hydrodynamic uplifting vertical forces or horizontal forces are impacting plant survival. After correlations have been made between seagrass survival and the magnitude of wave forces, threshold survival values can be selected for the various species. These species sensitive wave force threshold values can then be used for design of seagrass restoration and wave reduction features.

Utilizing the threshold values as design criteria, nearshore bars and topographic features can be evaluated for geometric shape and placement vs. the resultant wave force reductions. If they could be reconstructed using dredged material from harbor dredging projects, it might solve two problems: need for disposal sites and protection from large boat wakes. Temporary features may also be considered for use during plant establishment and evaluated for removal as seagrass becomes established over time.

In order to address these issues, a multiphase research and testing project has been proposed with a number of cooperating partners. The project is being coordinated by the Tampa Bay Estuary Program (TBEP), and includes in its cooperators, Coastal Resources Group, Inc. (CRG), Lewis Environmental Services, Inc., City of Tampa Bay Study Group (COTBSG), U.S. Geological Survey, Hillsborough County Environmental Protection Commission, Tampa BayWatch, Tampa Port Authority, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, and the Florida Department of Environmental Protection (FDEP). The first three tasks of the project are listed below.

Task 1. History and current distribution of seagrass bars through photointerpretation and GIS mapping.

Maps be would prepared of existing seagrass with bars particularly noted and color coded in ArcView 3.2 for four (4) time periods representing: (1) Baseline conditions when bars were in their most intact condition and can be interpreted from aerial photography. Likely date is circa 1940 as reference sheets from the National Archives showing complete black and white vertical aerial photographic coverage of Tampa Bay for 1938-1942; (2) Circa 1950, which is the baseline condition being used as a restoration target for TBEP planning purposes; (3) Circa 1980 when seagrass coverage was at its minimum in Tampa Bay and (4) Circa 2004 using the current rectified true color vertical coverage of Tampa Bay shot by SWIM and processed into digital form by the USGS and made available through the Tampa Bay Estuary Program and the USGS Tampa Bay Pilot Program.

Task 2. Characterize topography/bathymetry of existing bars in relationship to seagrass distribution (in cooperation with the COTBSG).

Task 3. Develop a conceptual model of a restored seagrass longshore bar system using the data gathered in Phases 1 and 2 (In cooperation with David Tackney, P.E., Coastal Engineer, Tackney and Associates, Tampa)

These three phases were funded in December 2004 with a grant through Cargill Plant Nutrition, Inc. (now Mosaic Fertilizer, LLC), to Coastal Resources Group, Inc., to prepare this data report describing, with ArcView maps, the trends in location, size and distribution of seagrass bars in Tampa Bay, and including information available from the COTBSG on bathymetry of seagrass meadows and bars from its ongoing transect monitoring program (Tampa Bay Interagency Seagrass Monitoring Program). Task 3 has produced two Environmental Resources Permit (ERP) applications to FDEP for transplanting seagrass to initiate bar formation (applicant Roy R. Lewis III, CRG), and to build four pilot longshore bars (applicant Tampa Port Authority).

Methods

Obtaining Historical Photography

Historical photography was obtained through a number of sources as high resolution digital scans for longshore bar mapping for the representative years of 1940, 1950, 1980, and 2004.

Index sheets retained at the University of Florida Map and Imagery Library, Gainesville, FL (http://www.ufliblufl.edu/), were used to identify and locate the appropriate reference aerial photo tiles for 1940, 1950, and 1980 time periods. The files included the index sheets for United States Department of Agriculture (USDA) flights back to 1937. The University of Florida in conjunction with the USDA has a continuing program to scan all historical USDA photography covering all of Florida. Index sheets were reviewed for Hillsborough, Pinellas, and Manatee counties. Criteria for determining the best photography was based on flight date for each time period, clarity and completeness of the photo series for the bay area. When a series was identified the index sheets were examined and identification numbers for the corresponding tiles were entered into a MS Excel table. Overlap between flight lines were then excluded resulting in full coverage of the target area and minimal time spent on examining duplicate images.

The circa 1940's representative photography selected included the Hillsborough 1938 BQF series, the Pinellas 1943 CYY series, and the Manatee 1940 CDO series. These images were readily available through the University of Florida Digital Library Center. Images were transmitted via TIF format on CD.

The circa 1950's representative photography selected, included the Hillsborough 1948 BQF, Pinellas 1951-1952 CYY, and Manatee 1951-1952 CDO. These images were available through the US Geological Survey as rectified photography. Images were obtained through communications with Kathryn Smith (USGS) and downloaded onto an external hardrive.

For circa 1980, we selected the 1982 Hillsborough 40-12057 series, the 1984 Pinellas HAP-84 series, and the 1980 Manatee 40-12021 series. The University of Florida collection did not include the actual 1980s images, therefore information derived from their index sheets was used to order those photos from the USDA Aerial Photography Field office in Salt Lake City, UT (http://www.apfo.usda.gov/). Photography was delivered in black and white images in TIF non-rectified format. Scale of the images 1:40,000 scale Hillsborough 1982 and Manatee 1980 photos at 25 microns and the 1:58,000 Pinellas 1984 photos at 17.5 microns so that they would all be at the same 1 m resolution.

Current 2004 aerial photography of Tampa Bay was flown by Southwest Water Management District in January 2004. Aerial photography is obtained every two years in accordance with the Surface Water Improvement and Management (SWIM) Act of 1987. A set of the rectified photography was obtained from Mote Marine Laboratory, Sarasota, FL.

Photo Interpretation and GIS Mapping

Digital mapping of the longshore bars was accomplished using AcrView 3.2a (Redding, Ca). Images were downloaded into the program and shapefiles created to digitize each time period as a separate file.

Photo interpretation was accomplished by examining both hard copies and digital photography. Photography during 1938-1942 was used for producing 1940's representative map. The photography was not available as a rectified product; therefore hardcopies of all photography were printed and identified longshore bars were manually located and marked on the hardcopy. Digital mapping of the bars was accomplished by using the rectified 1950's photography as a background and 1938-1942 hardcopies as a guide to the location and extent of the bars. To obtain quality assurance and control, prints of each mapped section overlaid on the 1950's rectified photography were used in comparison to the original 1938-42 hardcopies.

Rectified photography of the 1950's obtained through USGS was used directly as digital photointrepretation in ArcView. Bars were identified on screen and mapped as polygons. Prints of the individual mapped frames were examined for quality assurance.

Photography during 1980-84 was used for producing 1980's representative map. The photography was not available as a rectified product; therefore hardcopies of all photography were printed and identified longshore bars were manually located. Digital mapping of the bars was accomplished by using the rectified 1999 SWIM photography obtained through USGS, as a background and 1980-84 hardcopies as a guide to the location and extent of the bars. To obtain quality assurance and control, prints of each mapped section overlaid on the 1950's rectified photography were used in comparison to the original 1980-84 hardcopies.

Rectified 2004 photography and the use of the 2004 SWIM seagrass mapping, produced by GeoScience, St. Petersburg, FL. were used to produce current 2004 longshore bar mapping. Polygons embedded in the existing seagrass map that represented longshore bars were currently mapped as tidal flats in the 2004 SWIM seagrass mapping. The polygons were carefully examined for accuracy and edited if needed. The revised polygons were then re-labeled as longshore bars.

Quantification and Presentation

Upon completion of polygon mapping for the four time periods, new line files were created in ArcView 3.2a. The lines extended from the longest point of each polygon. Using the data base file in ArcView the length in meters were automatically calculated for each longshore bar polygon for each time period.

The line shapefile was then overlaid onto a shoreline layer. The 1940's shoreline was obtained through USGS using the 1879 shoreline and editing the file to represent what the shoreline would look like during the 1940's. The 1950's and 1980's shorelines were created by editing the existing SWFWMD 2004 shoreline. Maps were then finalized with representative shoreline and longshore bar layers.

Quantification of Tampa Bay Subdivisions

A new geographic description of boundaries and subdivisions of Tampa Bay were proposed in 1982 (Lewis and Whitman, 1985). The subdivisions were used to calculate shoreline length, although they also provide a useful way of looking at the length and number of longshore bars in a smaller scale in each of the bay sections. The sections include:1; Old Tampa Bay, 2; Hillsborough Bay, 3; Middle Tampa Bay, 4; Lower Tampa Bay, 5;Boca Ciega Bay, 6; Terra Ceia Bay, 7; Manatee River.

The same seven subdivisions of Tampa Bay were then added to the shoreline maps for each of the four time period. For each of the seven divisions the length and number of the mapped longshore bars were calculated using the same AcrView technique as described above.

Bathymetry

The COTBSG provided maps and associated graphics for the figures in this report (Figures 10-14) that illustrate change in bathymetry along five of the permanent transects being monitored for seagrass cover in Tampa Bay as part of the Tampa Bay Interagency Seagrass Monitoring Program.

Results

Quantification and Presentation

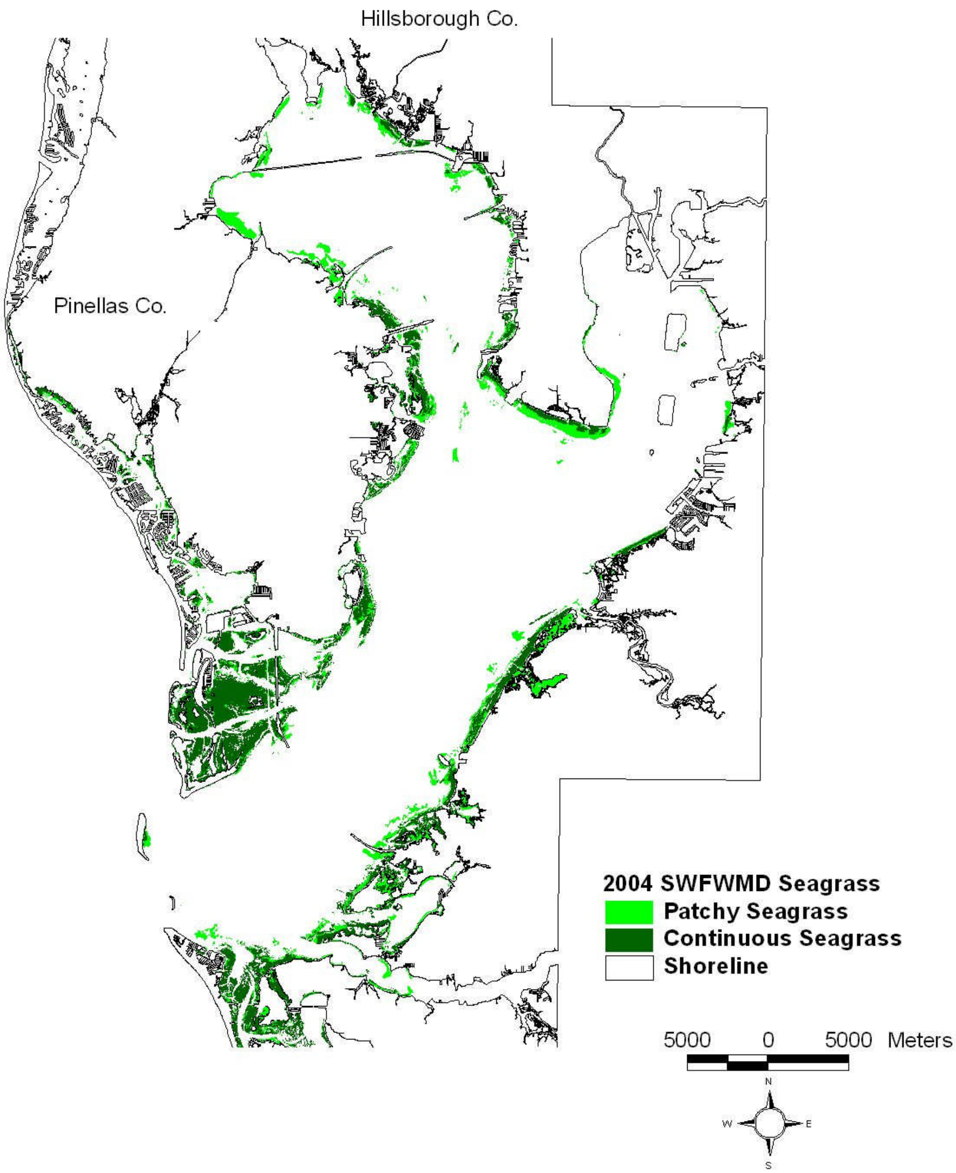

Figure 1. Map of project area, showing the locations of seagrass resources in the Tampa Bay region (based on 2004 aerial mapping data provided by the Southwest Florida Water Management District).

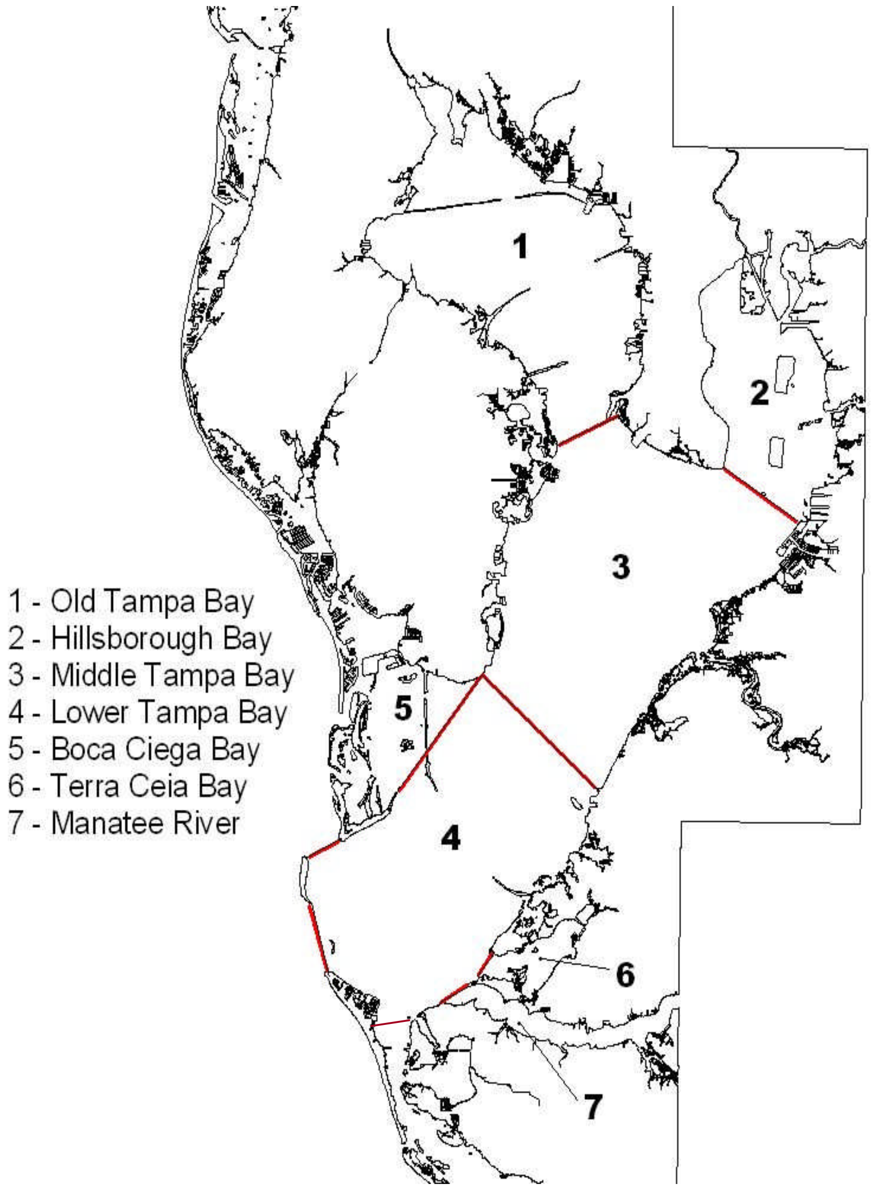

Figure 2. Location of the seven sub-divisions of Tampa Bay.

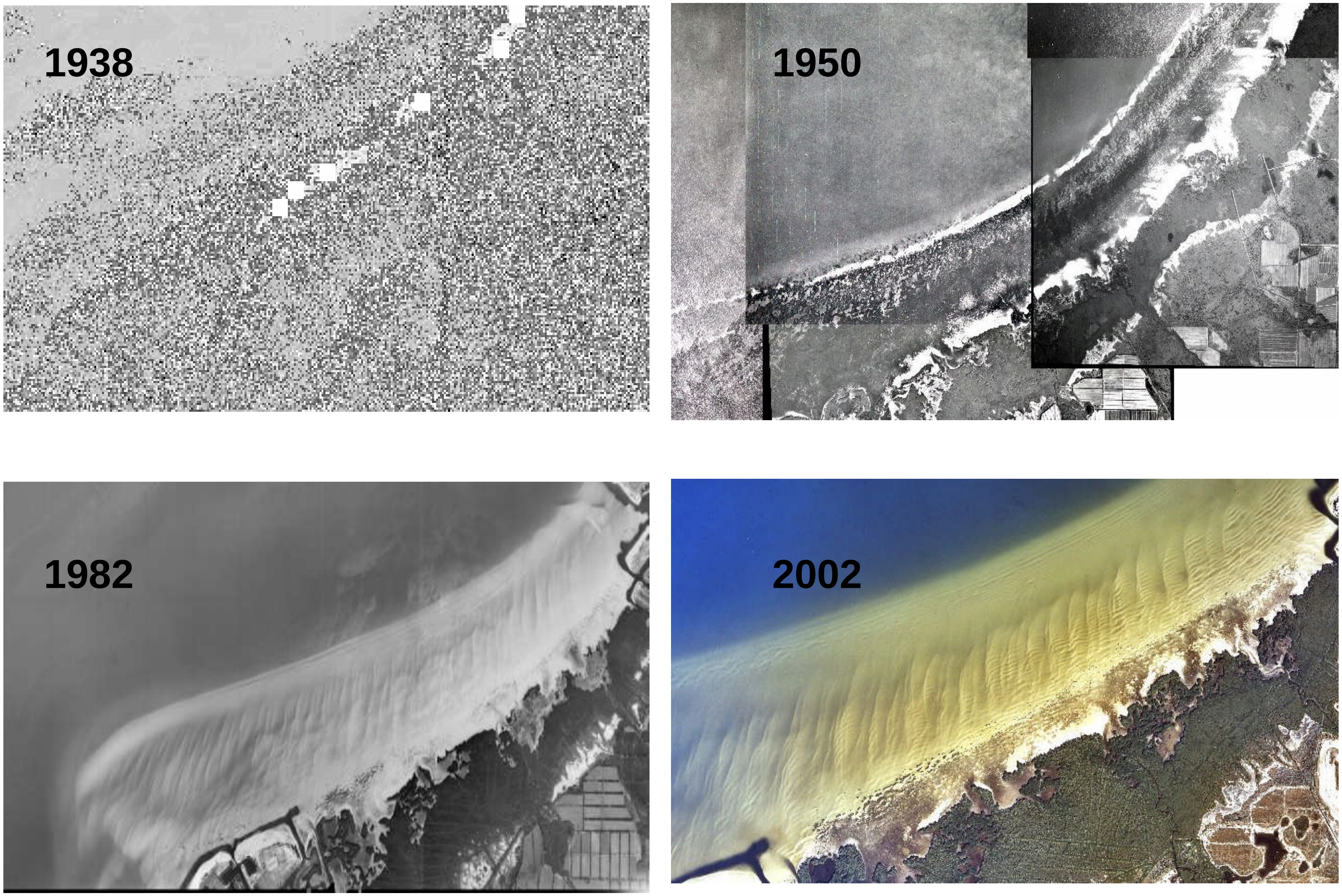

Figure 3. Wolf Branch seagrass bar aerials, 1938,1950,1982,2002.

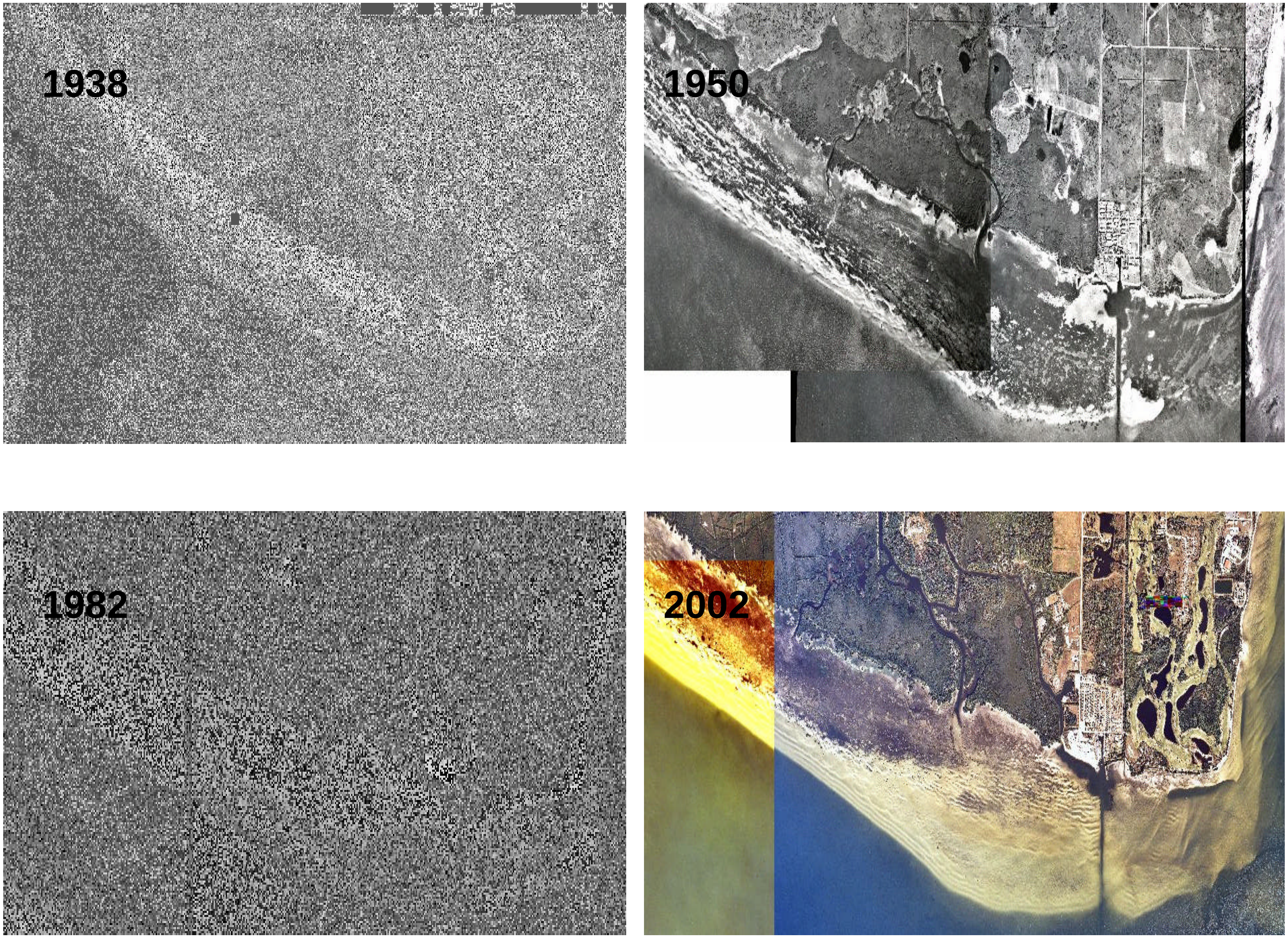

Figure 4. South Interbay Peninsula seagrass bar aerials, 1938, 1950, 1982, 2002.

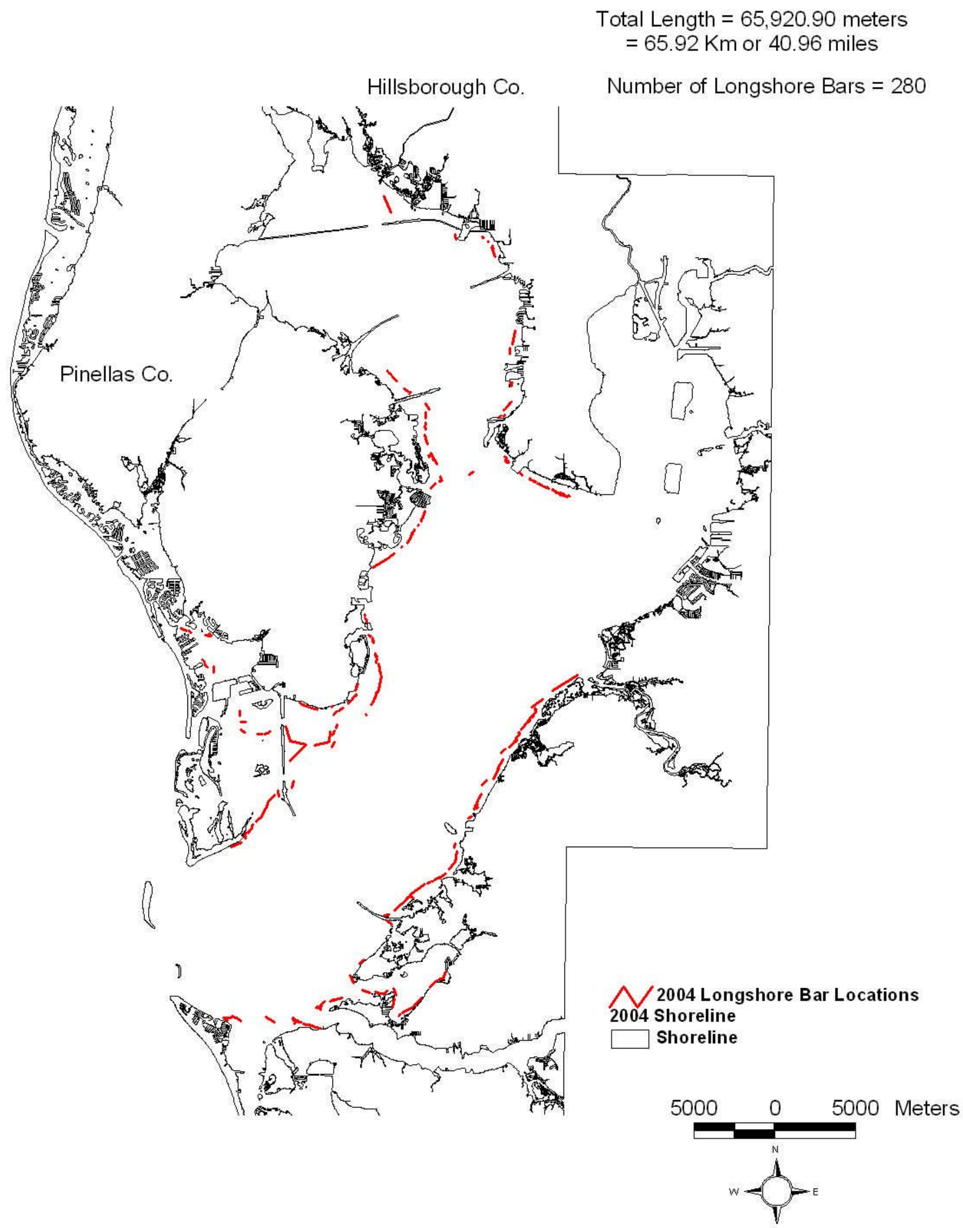

Figure 5. Map of project area, showing the locations of 2004 longshore bars (in red) in the Tampa Bay region (based on 2004 aerial mapping data provided by the Southwest Florida Water Management District).

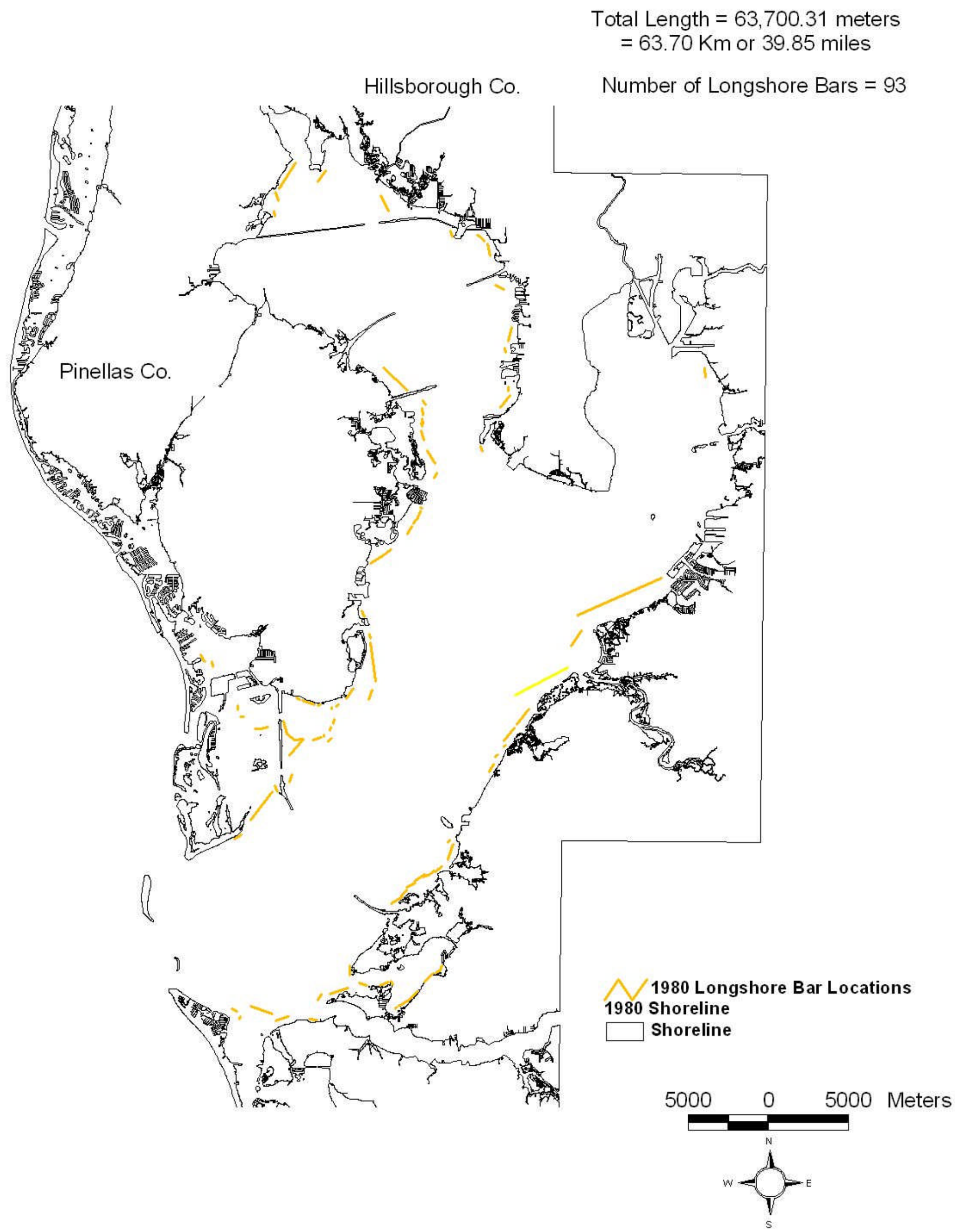

Figure 6. Map of project area, showing the locations of 1980's longshore bars (in orange) in the Tampa Bay region (based on 1990 aerial mapping data provided by the South West Florida Water Management District. Mapped longhsore bars identified using circa 1980's photography provided by University of Florida.

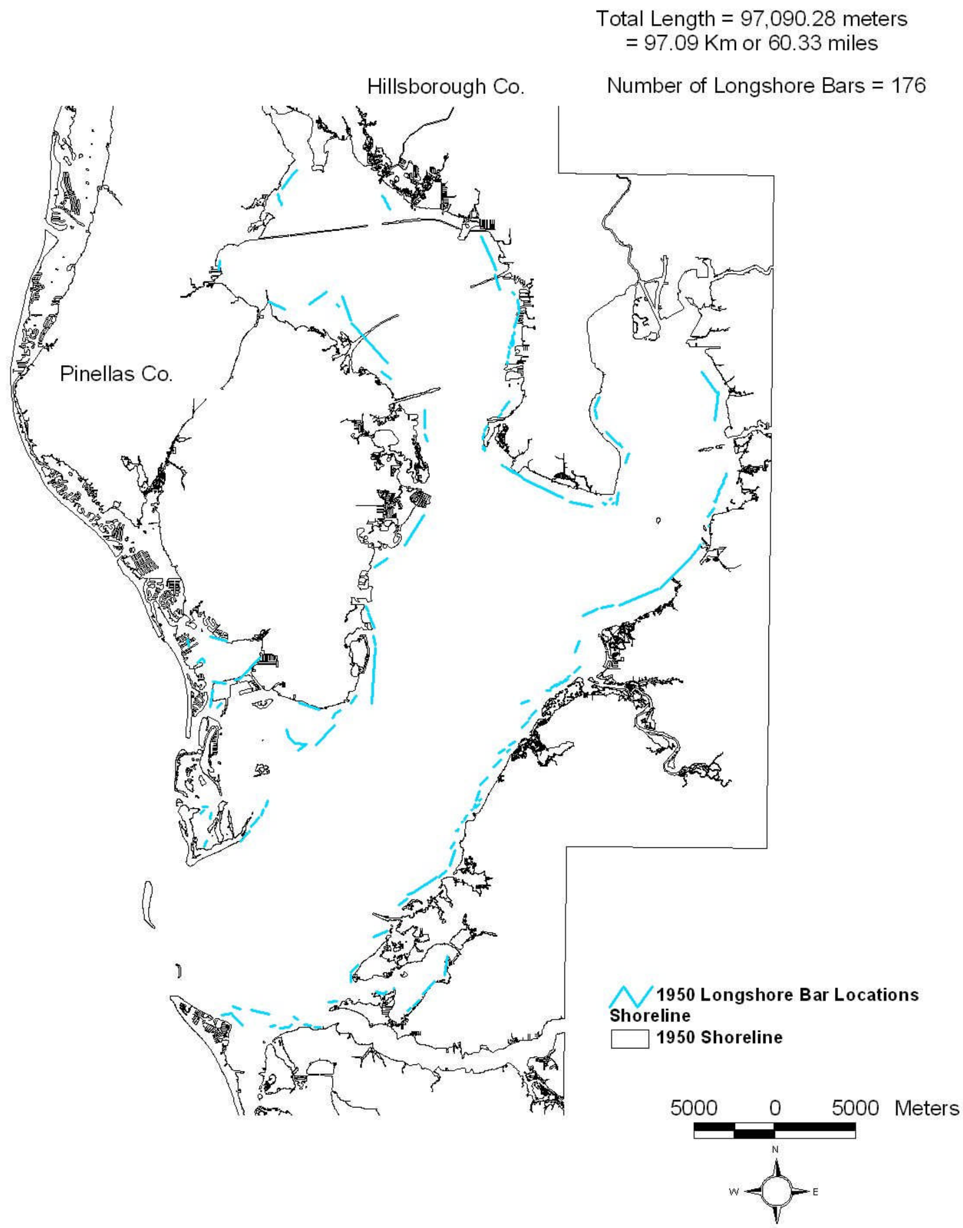

Figure 7. Map of project area, showing the locations of 1950's longshore bars (in blue) in the Tampa Bay region (based on 1950 aerial mapping data provided by Tampa Bay Estuary Program). Mapped longshore bars identified using circa 1950's photography provided by U.S. Geological Service.

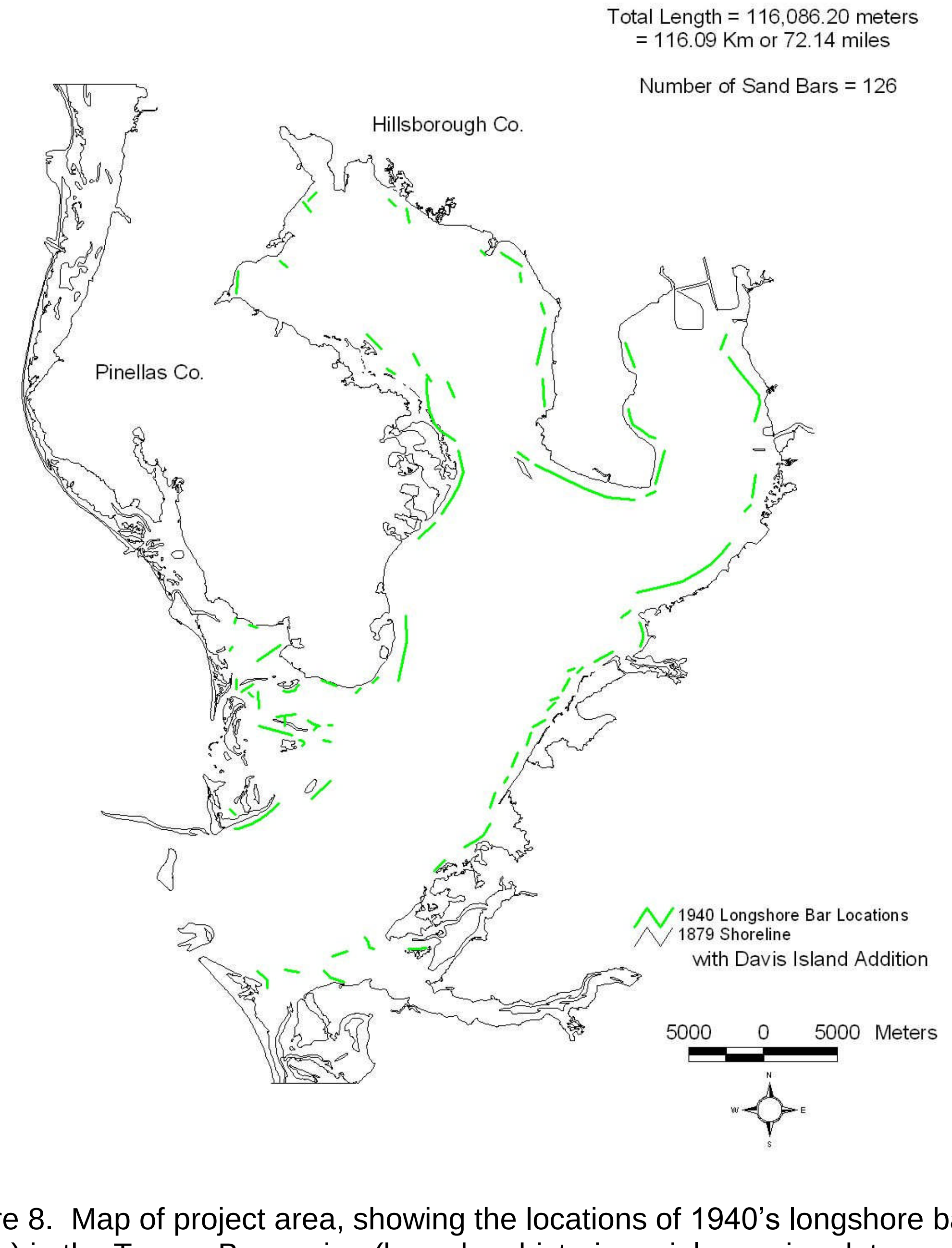

Figure 8. Map of project area, showing the locations of 1940's longshore bars (in green) in the Tampa Bay region (based on historic aerial mapping data provided by U.S. Geological Service). Mapped longshore bars identified using circa 1940's photography provided by University of Florida.

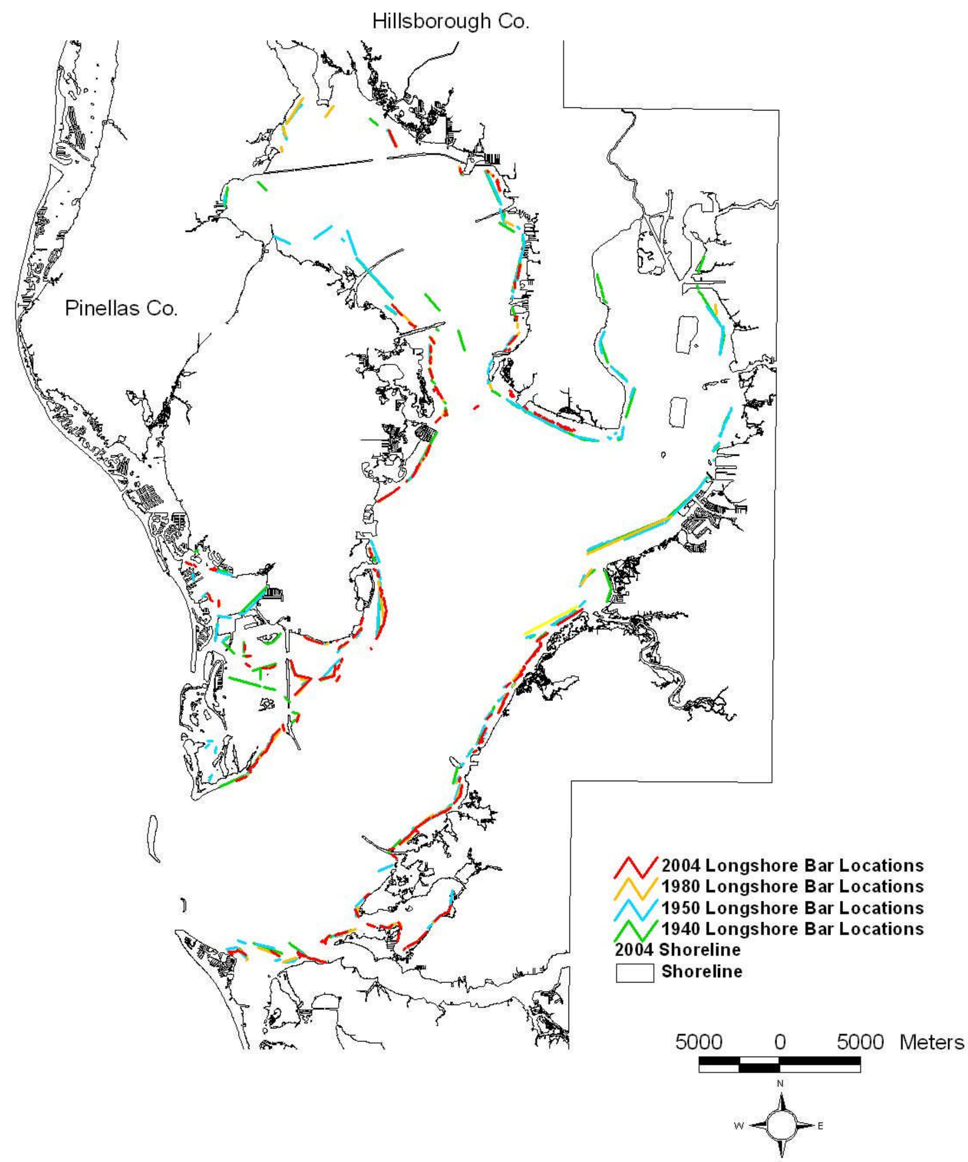

Figure 9. Map of project area, showing the locations of longshore bars in the four time periods, 2004, circa 1980, circa 1950, and circa 1940 in the Tampa Bay region.

Figure 10. Chart showing Total length of longshore bars for four time periods (2004, circa 1980, circa 1950, circa 1940).

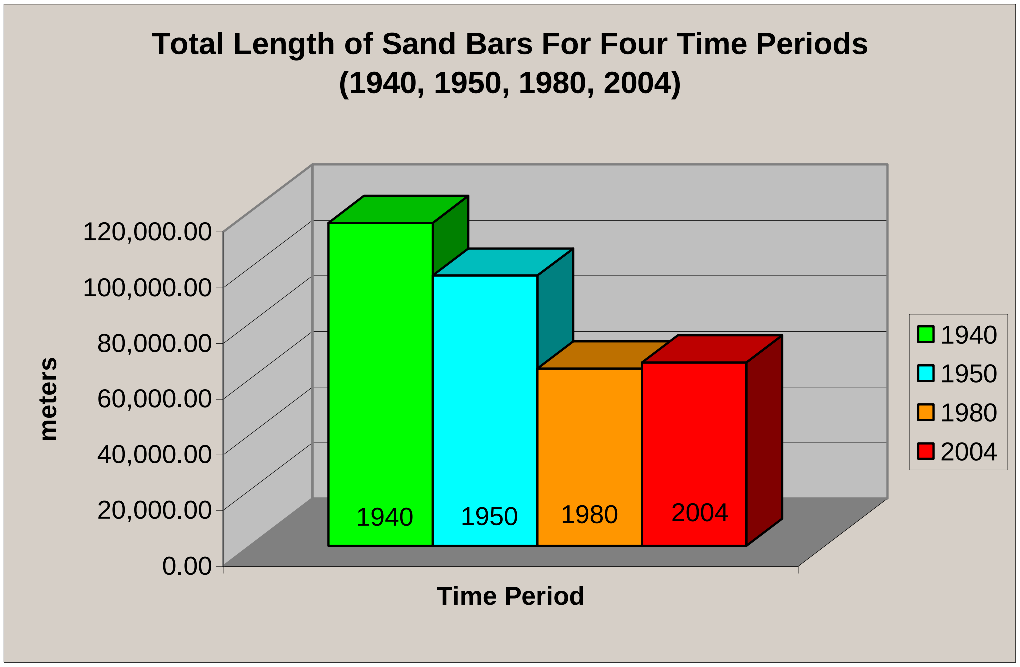

Figure11. Chart showing Total number of longshore bars for four time periods (2004, circa 1980, circa 1950, circa 1940).

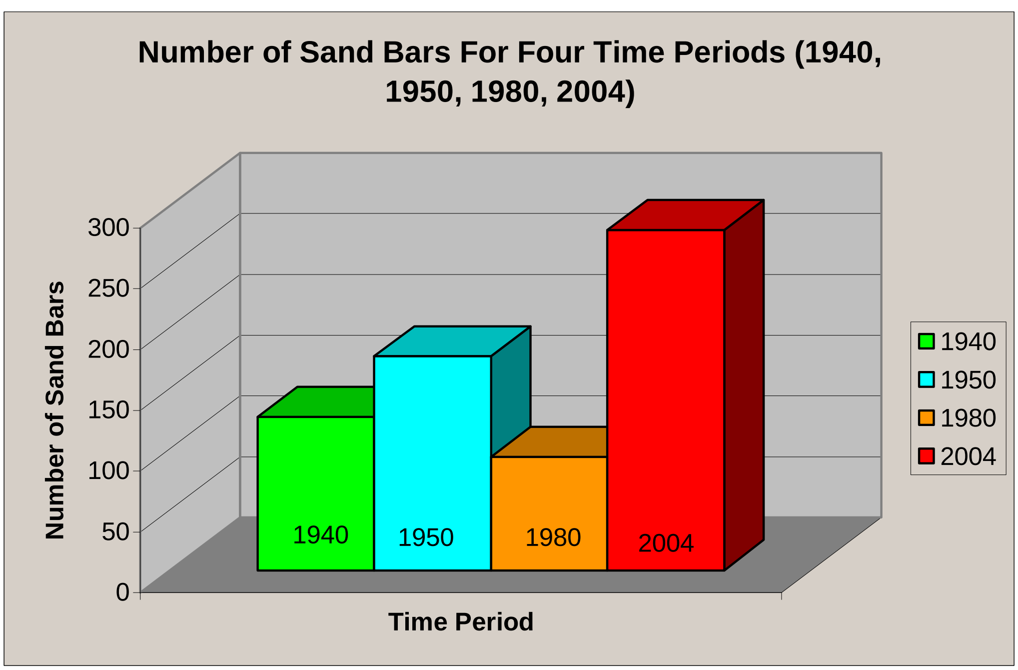

Table 1. Summary Table of total longshore bar length and total number of bars.

Time Period	Meters	Kilometers	Miles	Number of Bars
2004	65,920.90	65.92	40.96	280
1980	63,700.31	63.70	39.58	93
1950	97,090.28	97.09	60.33	176
1940	116,086.20	116.09	72.14	126

Figure 1 shows the project study area. Figure 2 shows the seven subdivisions of the bay. Figure 3 contains four vertical aerial photographs at approximately the same scale for the four time periods for the South Interbay Peninsula in Middle Tampa Bay. Figure 4 contains four vertical aerial photographs for the same time periods for the Wolf Branch area also in Middle Tampa Bay. Figures 5-8 show the results of the mapping for the four time periods: Circa 1940, 1950, 1980 and 2004. Figure 9 shows the combined information for all time periods on a single background map.

The results of the photointerpretation and mapping are summarized in Tables 1 and 2, and Figures 10 and 11. For the bay as a whole, the total length of longshore bars has decreased by approximately 50% (- 56.8%), while the number of longshore bars and more than doubled, from 126 circa 1940 to 280 in 2004 (+222%), after a sharp decline from 126 visible features circa 1940, to only 93 circa 1980. The decline in total length we attribute to the overall decline in seagrass meadow coverage during the same period, and the resulting loss of stabilizing cover on both the seaward and landward sides of the longshore bars as hypothesized by Lewis et al. (1985) and Lewis (2002). The initial decline, followed by the recent increase in numbers of bars we attribute to the same loss of stabilizing cover and now a gradual recovery process, but with smaller linear features which may, over time, coalesce to form more singular features. The process of decline in overall seagrass coverage coincident with loss of the longshore bar is apparent in the aerial photographs in Figure 4 for the Wolf Branch area of Middle Tampa Bay. The decline and recovery process is illustrated by the series of aerial photographs in Figure 3 for the south Interbay Peninsula area.

Quantification of Tampa Bay Subdivisions

Table 2. Distribution of Longshore Bars in each of the seven subdivisions for the four time periods 1940, 1950, 1980, and 2004.

Bay Sub Divisions	1940		1950		1980		2004	
	Length (m)	# Bars	Length (m)	# Bars	Length (m)	# Bars	Length (m)	# Bars
1 Old Tampa Bay	27,043.15	25	22,017.32	39	14,313.13	21	8,617.49	36
2 Hillsborough Bay	15,863.25	22	9,620.36	20	563.87	1	0.00	0
3 Middle Tampa Bay	34,575.44	34	32,206.35	58	21,985.78	22	22,732.34	135
4 Lower Tampa Bay	17,725.70	20	16,784.94	35	14,741.22	26	19,011.41	62
5 Boca Ciega Bay	18,564.44	20	11,565.79	17	6,635.09	12	9,260.22	32
6 Terra Ceia Bay	1,503.43	7	4,106.77	8	4,954.68	11	5,321.57	11
7 Manatee River	810.79	2	788.75	2	506.54	1	977.87	4
Total	**116,086.20**	**126**	**97,090.28**	**176**	**63,700.31**	**93**	**65,920.90**	**280**

For the various subdivisions of Tampa Bay, the greatest percentage decline in overall length of bars occurred in Hillsborough Bay, with 100% loss, and no recovery to date. For Old Tampa Bay the loss over the same period has been 68%. Lower Tampa Bay appears more or less stable, and Middle Tampa Bay has shown a decline of 34% in total length of bars. These changes are consistent with the perceived degrees of both dredging impacts, and water pollution and the associated decrease in seagrass cover documented for the same areas of the bay (Lewis et al. 1985, Lewis and Estevez 1988). While these results do not represent documentation of cause and effect, they are consistent with the hypothesis that loss of bars is associated with loss of seagrass cover (and visa versa), and that gradual recovery of seagrass cover and bar structure is occurring in some parts of Tampa Bay (i.e., south Interbay Peninsula).

Bathymetry

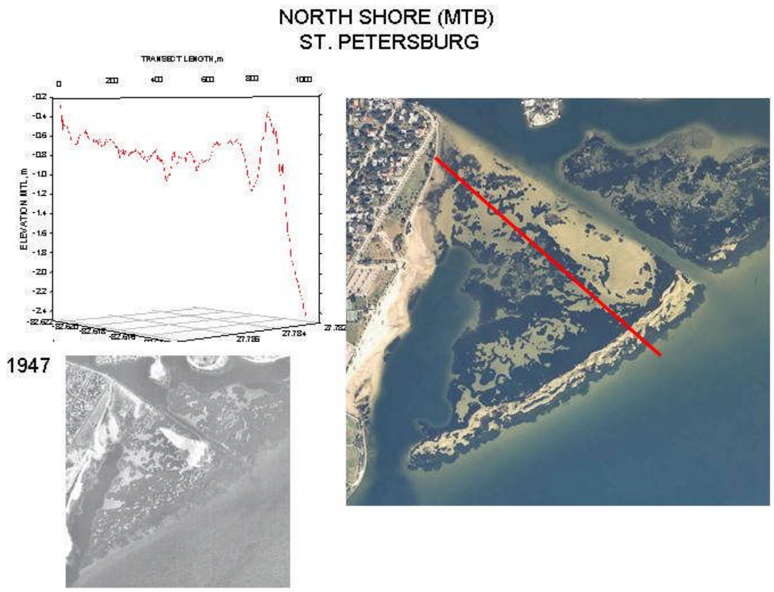

Figure 12. Coffeepot Bayou aerial photographs and COTBSG transect location (S3T11) and bathymetry (From the COTBSG).

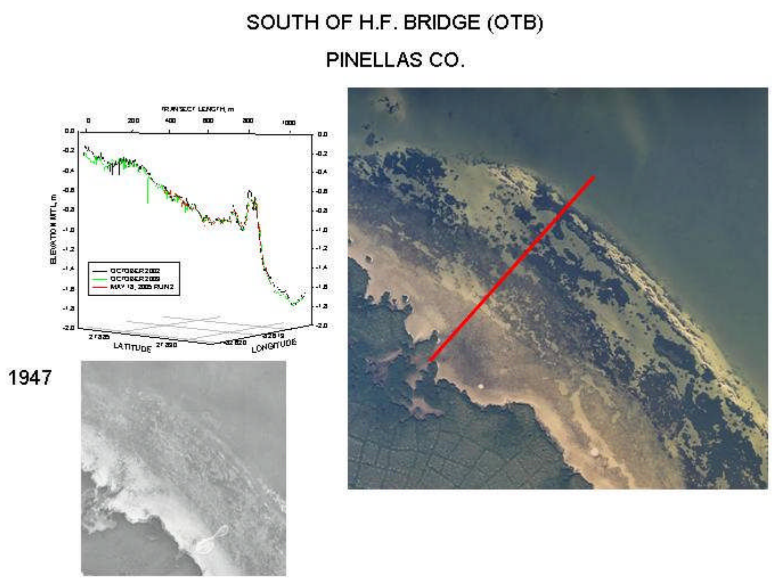

Figure 13. Pinellas County south of the Howard Franklin Bridge aerial photographs and COTBSG transect location (S1T16) and bathymetry (From the COTBSG).

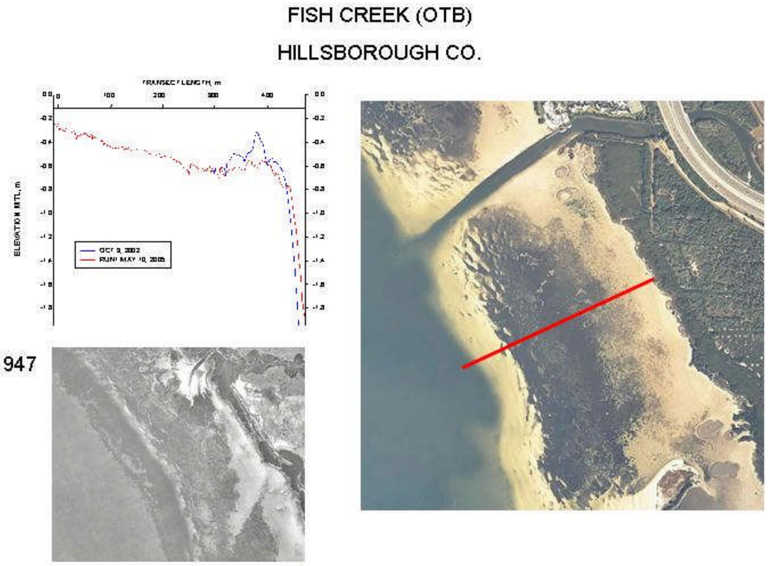

Figure 14. Fish Creek aerial photographs and COTBSG transect location (S1T5) and bathymetry (From the COTBSG).

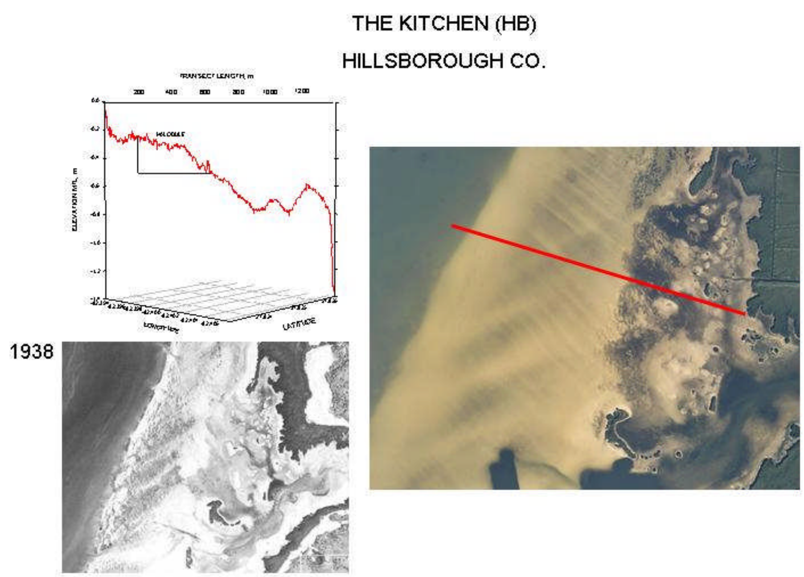

Figure 15. The Kitchen aerial photographs and COTBSG transect location (S2T2) and bathymetry (From the COTBSG).

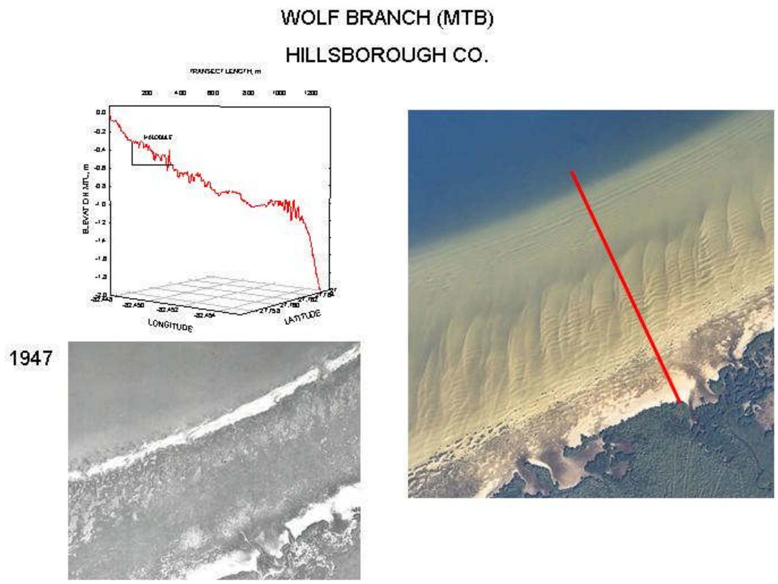

Figure 16. Wolf Branch aerial photographs and COTBSG transect location (S3T13)and bathymetry (From the COTBSG).

Figures 12-16 show a comparison of aerial photographs and bathymetry across the seagrass meadow present in the five areas of the bay. The figures were prepared by the COTBSG. They illustrate what we interpret to be the sequence of bar decline and loss as a distinct feature, and the simultaneous decline in seagrass cover, with initial loss offshore around the bar as seen in Figure 14 at Fish Creek in Old Tampa Bay. Figures 15 and 16 at the Kitchen in Hillsborough Bay, and Wolf Branch in Middle Tampa Bay, represent the resulting loss of nearly all the seagrass except for a narrow band of inshore shoal grass (*Halodule wrightii*) in shallow water. Figures 12 and 13 represent more stable long-term seagrass meadows at Coffeepot Bayou in Middle Tampa Bay and south of the Howard Franklin Bridge on the west side of Old Tampa Bay. Both have obvious longshore bar features that are shallower in bathymetry than the immediately adjacent seagrass meadows on both sides (seaward and landward). We believe these are consistent with the working hypotheses regarding bar stability that state that a longshore bar is dependent on a band of seagrasses located just offshore of the bar feature for its long-term existence, but more research is needed to further elucidate how these apparently interdependent features (i.e., the shallow largely unvegetated longshore bar and the seagrass meadows both inshore and offshore of the bar) interact to create conditions conducive to the existence and persistence of large expanses of inshore seagrass meadows at certain locations in Tampa Bay.

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