Inlet Dynamics from Semi-Annual Surveys

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1. Introduction

Field surveys, carefully conducted with state-of-the-art equipment, remain the best source of information for studying tidal inlets. Data from an ambitious hydrographic surveying program that is ongoing at Sebastian Inlet, Florida (see Figure 1), are being analyzed to examine the morphologic dynamics of the inlet, to maintain a sediment budget, and to identify any ongoing impacts of the inlet to the adjacent beaches.

Historically, the presence of Sebastian Inlet caused the formation of both ebb and flood shoals, and accretion and erosion along the beaches to the north and south, respectively. However, because 1) the inlet is relatively small, 2) its jetties were originally constructed in 1923-24, and 3) a sediment trap in the inlet's throat is periodically dredged and the material placed on the downdrift beaches, any persistent, long-term erosion/accretion trends have abated. Modern-day changes are limited to variation about a quasi-equilibrium state (Dally and FitzPatrick, 1997).

The predominant wave energy along the east central Florida coast during the winter months emanates from the north and northeast sectors due primarily to extratropical storms commonly referred to as 'northeasters'. It is thus expected during the winter months sand will accrete at the north side of the inlet, and erode from the south. During the summer months, the direction of predominant wave energy switches to the southeast quadrant. Low-energy 'recovery' swell is caused by persistent winds from an entrenched system of high pressure (Bermuda High) which dominates the summer weather in the central North Atlantic. Higher energy swell from this sector also occurs as a result of occasional hurricanes. Consequently during the summer, erosion of the north fillet is expected, with accretion on the south. The purpose of the study described below is to identify and quantify this seasonal behavior, and any other patterns or trends present.

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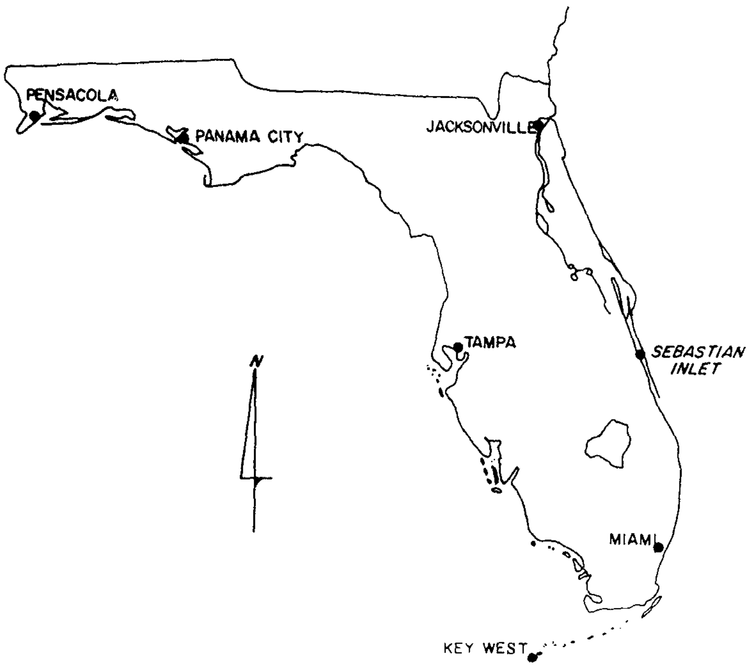

Figure 1 - Location of Sebastian Inlet, on Florida's central Atlantic coast.

2. The Survey Data Set

The data set used in this study consists of 15 surveys of the Sebastian Inlet system, which cover the flood shoal, navigation channel, sediment trap, inlet throat, ebb shoal, and north and south beaches. Figure 2 presents a plan view of the data coverage from a recent survey. Although an initial survey was conducted in August, 1989, surveys have been performed on a semi-annual basis since July, 1990, usually in February and July.

Although the equipment and techniques used in the surveying program are continually improved, in general, standard land surveying methods are used to wading depth, with boat/fathometer methods used in deeper water. Transect spacing in the ebb shoal, sand trap, and navigation channel is 100 ft, whereas the spacing in the inlet throat and flood shoal is 200 ft. Beach profiles are measured at 500 ft or 1000 ft intervals, and are based upon the system of monuments ('R-monuments') maintained by the Florida Department of Environmental Protection. The spatial coverage, resolution, and semi-annual basis of the surveys makes this a distinctive data set, from which seasonal changes at Sebastian Inlet can be determined.

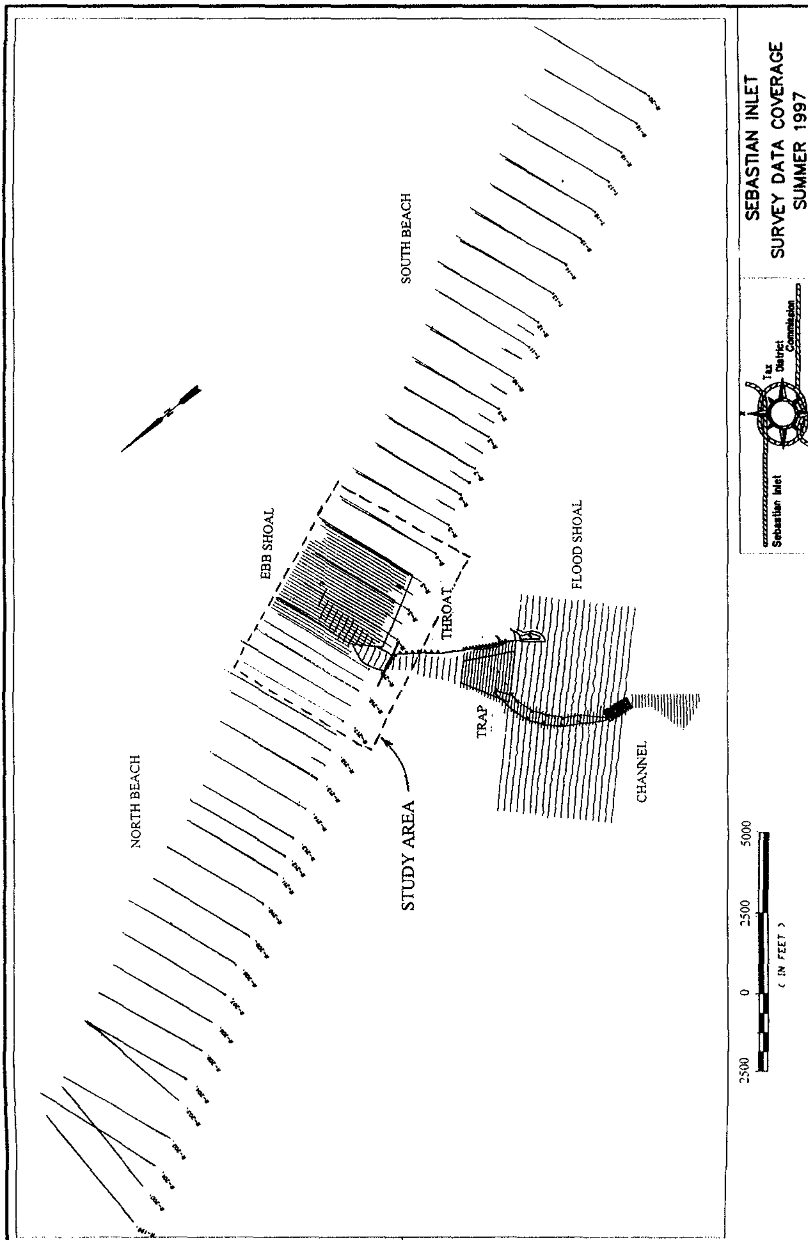

Figure 2 - Plan view of data from July 1997 survey of Sebastian Inlet, showing area used in studying fillets and ebb shoal .

3. Analysis Methods

For the purposes of studying morphodynamics in the immediate vicinity of the mouth of the inlet, herein the study domain was limited to 6000 ft (1830 m) in the longshore direction, from R-217 in Brevard County to R-004 in Indian River County. In the seaward direction, the domain extended roughly 5000 ft (1524 m) offshore, as is shown in Figure 2.

The survey data were analyzed using commercially available Digital Terrain Modeling software, specifically, the *Eagle Point* Civil Engineering Series (v. 13.2) that runs using AutoCAD (v. 13) as an operating platform. The *Eagle Point* Surface Modeling module was first used to create a three-dimensional representation of each survey by generating a Triangular Irregular Network (TIN), from which maps of bathymetric contours were created. The TINs created for each data set were then used to develop difference-contours, i.e contours of the changes in bathymetry that occurred between sequential surveys. Using maps of these difference contours, seasonal behavior of the inlet could be examined synoptically. Finally, the Site Design module of *Eagle Point* was used to make volumetric computations, in order to quantify seasonal changes to the inlet system.

4. Results and Discussion

4.1 Difference Contours

Difference contours were developed between consecutive seasonal surveys, beginning with 7/90 and concluding with 7/97, and allow one to examine the Sebastian Inlet region in a synoptic fashion. Two-foot contour intervals were used in order to identify areas where change was significant, and Figure 3 presents an example of typical results for a winter-to-summer comparison (2/94-7/94). The elevation contours of the earlier survey are also shown for reference. The area of the north fillet closest to the north jetty experienced up to 8 ft (2.4m) of erosion, with the amount of erosion decreasing northward. In contrast, the area of accretion in the south fillet extends over a larger area, between R-001 and R-003 (at which point the ebb shoal ties into the beach), but shows only up to 4 ft (1.2 m) of accretion. Although relatively inactive during this particular time period, the ebb shoal has a small spot of 2 ft (0.6 m) of accretion on its seaward flank, and a slightly larger spot of erosion on its landward side. An area of accretion is found directly off the end of the north jetty.

The 7/94-2/95 comparison shown in Figure 4 displays typical behavior for summer-to-winter changes. Extensive and significant accretion of up to 8 ft (2.4 m) is found on the north fillet whereas the south fillet experienced up to 6 ft (1.8 m) of erosion. As mentioned in the introduction, northeasters and other lesser storms cause sand to accrete as it becomes trapped against the north jetty, at the expense of the south fillet. In contrast to the previous season, the ebb shoal experienced significant (and reversed) change. A broad area of up to 6 ft (1.8 m) of accretion is seen on the landward side of the shoal, and erosion, but to a lesser degree is found on the seaward flank.

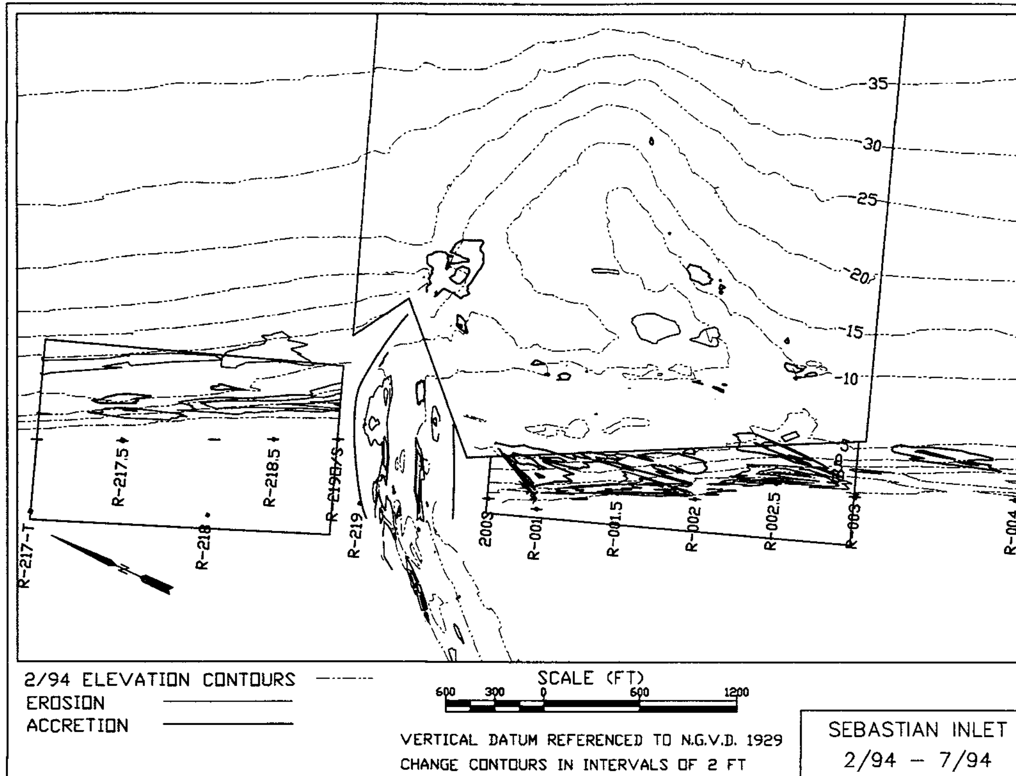

Figure 3 - Bathymetry and difference-contours for 2/94 - 7/94 surveys showing erosion of north fillet and accretion on south fillet, with only minor change to ebb shoal.

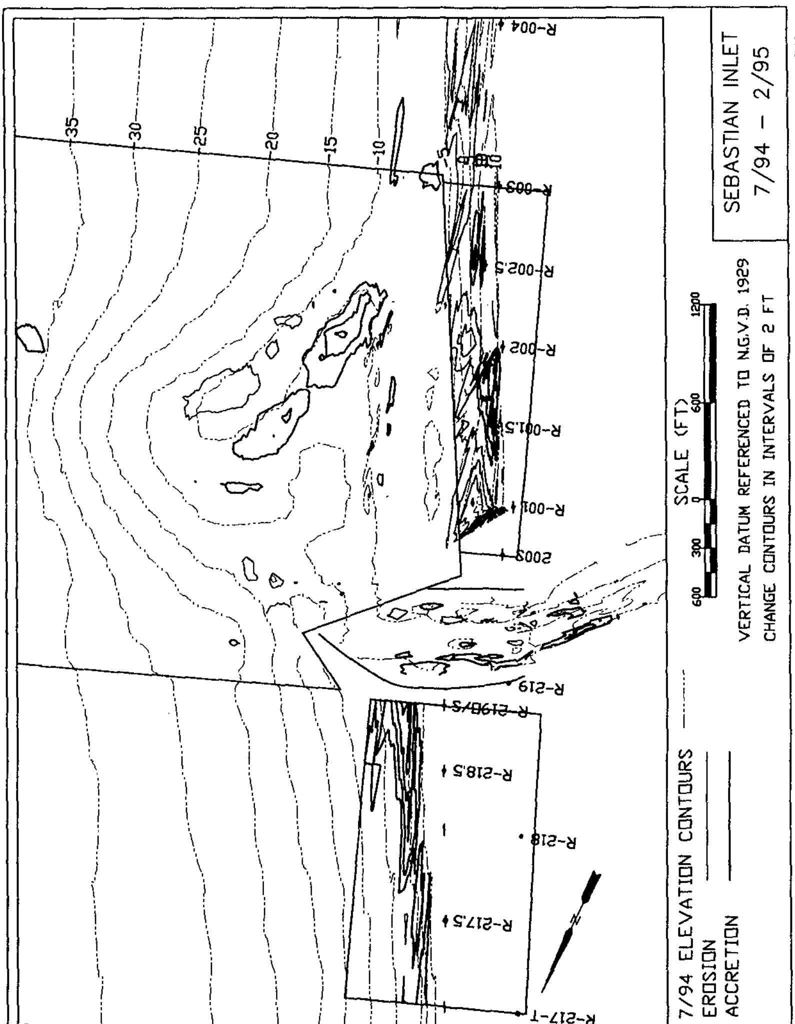

Figure 4 - Bathymetry and difference-contours for 7/94 - 2/95 surveys showing accretion on north fillet and erosion of south fillet, with moderate shift of material on ebb shoal.

The typical seasonal changes displayed by Sebastian Inlet in Figures 3 and 4 confirms expectations, given the usual seasonal shift in wave climate characteristic of the region. That is, high-energy, short-period, erosive waves from the northeast are typical during the late fall and winter, with low-energy, long-period, accretive swell from the south during the summer.

Although most seasonal changes experienced by Sebastian Inlet are qualitatively similar to those of Figures 3 and 4, the results from the 2/91-7/91 and 7/91-2/92 comparisons are significantly different. The difference-contours presented in Figure 5 show erosion as expected at the north fillet. Significant accretion is displayed by the south fillet region extending from the beachface to the -10 ft (-3 m) contour. The ebb shoal shows an area of mild accretion that is broader than would be considered normal, and little erosion is found on the leeward side of the shoal. It is noted that in 2/91, severe weather precluded boat/fathometer surveying of the north and south beaches, and reduced the coverage of the ebb shoal.

The 7/91-2/92 comparison of Figure 6 displays essentially a pattern reversed from the previous season but with even stronger change, especially on the ebb shoal. Uncharacteristically, erosion of the ebb shoal is widespread, typified by changes of 2 ft (0.6 m). Although these findings were originally viewed with skepticism, the field notes and reduced data were checked exhaustively, and the tide stage corrections for the boat survey verified. It is also noted that the large changes observed on the north and south fillets were documented using land surveying techniques, and were not subject to boat-survey errors. It is believed that the changes to the ebb shoal were real, and possibly caused by waves from the 'Halloween Storm' of late October, 1991. These waves were not only large ($H_{m0}\approx2.5$m), but more importantly were atypically long for the region ($T_m\approx20$s), and so were capable of mobilizing sand at even the 20 ft (6m) depth contour.

4.2 Volume-Change Computations

Volume changes were computed for the three specific domains examined above, in order to quantify their seasonal behavior. Indicated in Figures 3-6, the north fillet domain extended from R-217 to R-219 o/s - a distance of 1800 ft (549 m), and extended seaward to roughly -10 ft (-3 m) NGVD, a distance of 1000 ft (305 m). The south fillet domain extended from R200-S to R-003, which is 2250 ft (686 m) in the longshore direction. The south fillet domain was extended offshore to only -5 ft (-1.5 m) NGVD in order to capture changes in the south fillet while excluding the ebb shoal. The ebb shoal domain extended seaward 3275 ft (998 m), and 3248 ft (990 m) in the longshore direction, and its border cut diagonally across the jetty mouth.

In order to calculate volumes within the selected domains, the Site Design module in *Eagle Point* was used to superimpose the TINs in pairs sequentially, to determine raw cut and fill volumes within the area of interest. The computed cut and fill volumes were then used to obtain a net volume change within a domain for each season.

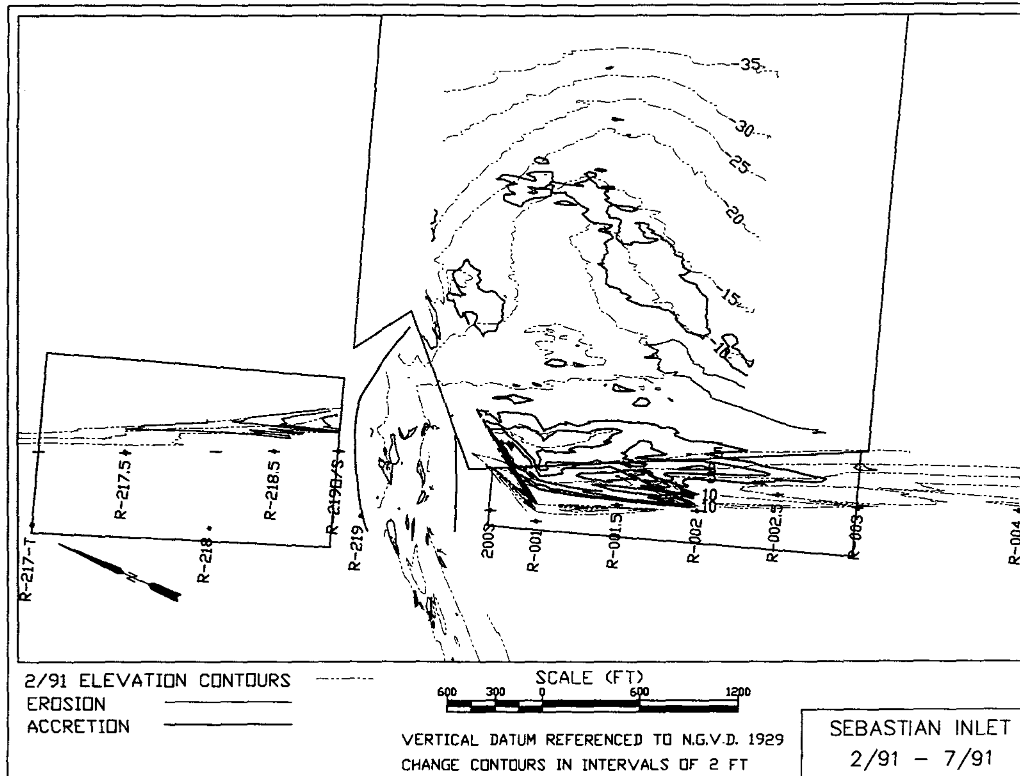

Figure 5 - Bathymetry and difference-contours for 2/91 - 7/91 surveys showing erosion of north fillet and major accretion on south fillet, with significant deposition on ebb shoal.

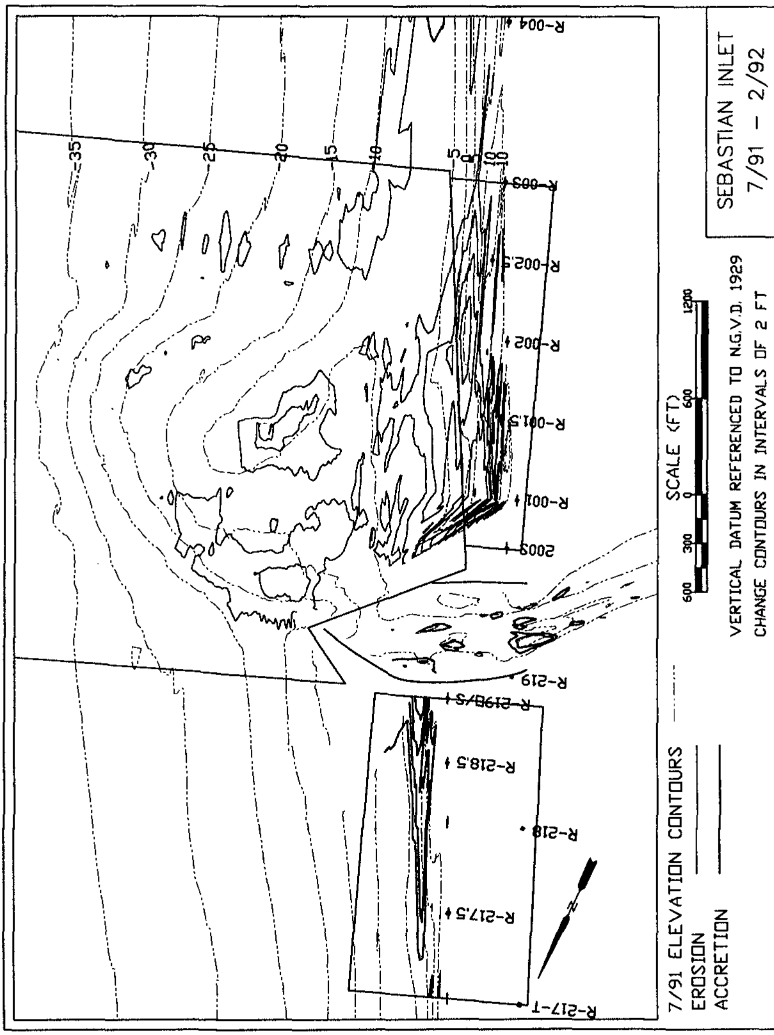

Figure 6 - Bathymetry and difference-contours for 7/91 - 2/92 surveys showing accretion on north fillet, and significant erosion of south fillet and ebb shoal attributed to long-period waves of the 'Halloween Storm'.

North Fillet

Results for the north fillet are presented in Table 1 and Figure 7. Of the fourteen seasonal comparisons made, eleven fit the expected pattern of accretion during the summer-to-winter transition and erosion in the winter-to-summer. Three comparisons displayed behavior not expected at the north fillet. The 7/90-2/91 comparison had a net

Season	North	Cumulative Volume (CY)
7/90-2/91	-10,856	-10,856
2/91-7/91	-20,525	-31,381
7/91-2/92	31,223	-158
2/92-7/92	22,225	22,067
7/92-2/93	11,542	33,609
2/93-7/93	2,636	36,245
7/93-2/94	36,056	72,301
2/94-7/94	-33,536	38,765
7/94-2/95	45,097	83,862
2/95-7/95	-20,408	63,454
7/95-2/96	640	64,094
2/96-7/96	-41,067	23,027
7/96-2/97	21,577	44,604
2/97-7/97	-992	**43,612**

Table 1. Volume Change Calculations for North Fillet.

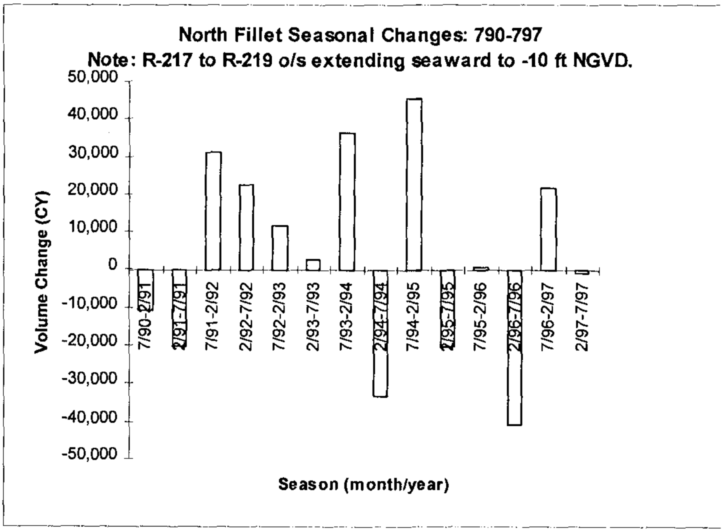

Figure 7. Volume Changes for North Fillet.

loss of 10,856 yd^3 (8,300 m^3) when a net accretion would have been expected. During the 2/92-7/92 season a net accretion of 22,225 yd^3 (16,992 m^3) was observed when erosion might be expected. Finally, there was a net accretion of 2,636 yd^3 (2015 m^3) for the 2/93-7/93 surveys, but this quantity is not significant. Noting the seasonal and annual variability, the net cumulative volume of 43,612 yd^3 (33,344 m^3) from 7/90 to 7/97 also is not wholly significant, and indicates that the north fillet was experiencing no net trend towards erosion or accretion during this time.

It is noted that the volume-change calculations were repeated for the north domain, but with the seaward boundary reduced to -5 ft (-1.5 m^3) NGVD to be consistent with the south fillet domain. The seasonal volume changes were identical in their pattern, but generally smaller in magnitude. A nct cumulative volume of 13,306 yd^3 (10,173 m^3) was computed in this smaller domain.

South Fillet

In the south fillet domain, ten of the fourteen comparisons showed erosion in the summer-to-winter and accretion in winter-to-summer, as shown in Table 2 and Figure 8. Of the four comparisons that displayed rcversed behavior for the south fillet, (i.e. 7/92-2/93, 2/94-7/94, 7/95-2/96, and 7/96-2/97), only 7/96-2/97 was significant (16,511 yd^3 accretion). The net cumulative volume of 50,039 yd^3 (38,258 m^3) found on the south fillet is significant in that it is accretion, and is larger than the net cumulative volume of 43,612 yd^3 (33,344 m^3) found on the north fillet for the same time period.

Season	Volume (CY)	Cumulative Volume (CY)
7/90-2/91	-3,200	-3,200
2/91-7/91	58,793	55,593
7/91-2/92	-60,787	-5,194
2/92-7/92	28,202	23,008
7/92-2/93	5,488	28,496
2/93-7/93	6,366	34,862
7/93-2/94	-33,666	1,196
2/94-7/94	-983	213
7/94-2/95	-19,995	-19,782
2/95-7/95	15,207	-4,575
7/95-2/96	2,675	-1,900
2/96-7/96	20,206	18,306
7/96-2/97	16,511	34,817
2/97-7/97	15,222	**50,039**

Table 2. Volume Change Calculations for South Fillet.

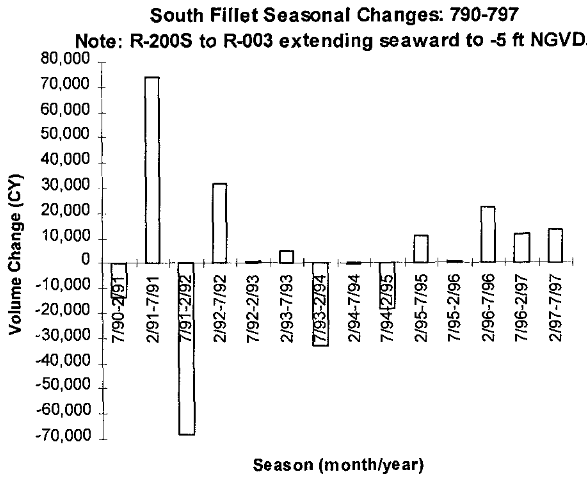

Figure 8. Volume Changes for South Fillet.

Ebb Shoal

It appears from the fourteen comparisons made for the ebb shoal domain, presented in Table 3 and Figure 9, that although half showed erosion and half accretion, no clear seasonal pattern exists. Overall, when accretion happens, it occurs at a fairly uniform rate, whereas erosion is much more variable. During the erosion episode in 7/91-2/92,

Season	Volume	Cumulative Volume (CY)
7/90-2/91	-47,507	-47,507
2/91-7/91	203,140	155,633
7/91-2/92	-444,574	-288,941
2/92-7/92	155,133	-133,808
7/92-2/93	107,755	-26,053
2/93-7/93	-33,847	-59,900
7/93-2/94	-53,565	-113,465
2/94-7/94	118,075	4,610
7/94-2/95	120,203	124,813
2/95-7/95	-143,411	-18,598
7/95-2/96	140,297	121,699
2/96-7/96	-13,647	108,052
7/96-2/97	-75,386	32,666
2/97-7/97	14,502	**47,168**

Table 3. Volume Change Calculations for Ebb Shoal.

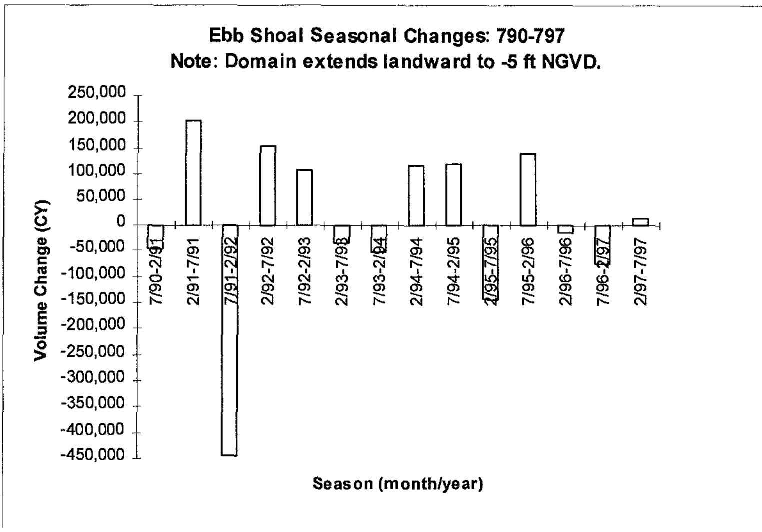

Figure 9. Volume Changes for Ebb Shoal.

more than 440,000 yd^3 (336,660 m^3) of sediment was lost from the shoal. The lack of seasonal pattern on the ebb shoal is attributed to the fact that, in addition to the wave climate, the hydrodynamics here are governed by the flood and ebb currents, which of course vary in the long-term according to general trends in ocean and lagoon water levels.

5. Conclusions

Clear patterns of seasonal behavior occur in the north and south fillet domains of Sebastian Inlet; however, the ebb shoal appears to experience gradual accretion and episodic erosion. All three domains show cumulative accretion for the seven-year time period, with that on the south fillet being the most significant as it is contrary to 'conventional wisdom' for the Atlantic coast of Florida. Further interpretation of these findings awaits detailed study of the long-term wave climate, meteorology, and water levels for the region.

6. References

Dally, William R., Ph.D., P.E. and FitzPatrick, Kathy, P.E. Survey-Based Sediment Budget Analysis For Sebastian Inlet, Sebastian Inlet Tax District Commission, Indialantic, Florida, 1997, 121 pp