5. SURVEY FINDINGS

Based on the analysis of the recent field data presented in Section 4, a judgement can be made concerning the relative stability exhibited by the five characteristic shoreline types mentioned previously (mainland bluffs, mainland spits, low mainland shore, Flaxman Island bluffs, and the barrier islands). This section of the report will assess those areas which have exhibited relative long-term stability (the first three categories listed above) and those which have proven to be less stable (Flaxman Island bluffs and the barrier islands) over the period of record.

5.1 Areas of Relative Shoreline Stability

The mainland coast of the study area exhibits a high degree of stability. While all three shoreline classes occurring on the mainland (the bluffs, spits, and low shore) have exhibited a high degree of stability, the bluffs and spits tend to be more dynamic than the low mainland shore. These three types of mainland coastal terrain will be discussed individually to illustrate the findings that support this general conclusion.

5.1.1 Mainland Bluffs

Three coastal transects were surveyed over mainland bluffs that achieve heights in excess of nine feet. The survey results are presented in Table 5.1, which show that the average bluff erosion for the July-September, 1982, period was 1.3 feet while the fronting beach at these sites eroded an average distance of 1.1 feet.

TABLE 5.1 : CHANGES IN MAINLAND BLUFFS, 1982

SUMMARY OF SURVEY DATA - MAINLAND BLUFFS

(ALL MEASUREMENTS EXPRESSED IN FEET)

TRANSECT	BEARING (Deg)	TRANSECT LENGTH		SOUTH WL TO MNT		MNT TO NORTH WL		ELEVATIONS		SHORELINE CHANGE AT JULY SWL DATUM	
		JULY	SEPT	JULY	SEPT	JULY	SEPT	ON MNT	SEPT SWL	SOUTH SHORELINE	NORTH SHORELINE
2	024.T	142	142			131	132	10.2	-.3		.8 EROSION
											.7 EROSION (BLUFF)
5	000.T	108	103			74	73	19.0	-.2		2.3 EROSION
											3.1 EROSION (BLUFF)
34	056.T	104	107			98	101	10.0	-.6		.3 EROSION
											0.0 EROSION (BLUFF)

AVERAGE SHORE CHANGE : 1.1' EROSION

AVERAGE BLUFF CHANGE : 1.3' EROSION

Due in part to the protection provided by the sand and gravel beaches existing at the base of the bluffs, bluff recession along the majority of the mainland shore is relatively mild. At several unsurveyed locations, however, extensive bluff recession was observed in spite of the energy-dissipating beachfront, as shown in Photo 2, taken near Transect #5. The major mechanism of bluff erosion in this case is the thawing and subsequent failure of the ice-laden bluff sediments.

5.1.2 Mainland Spits

Spits composed of sand and gravel project from a number of mainland promontories within the study area. These low-lying, sinuous sedimentary structures are formed by persistent littoral transport that constantly serves to nourish the spits. Gravel spits protect the mainland shore located to the south by dissipating incoming wave and ice forces.

Photo 3 shows a typical coastal spit located at Transect #27. This spit projects westward from the Pt. Thomson pad location, which can be seen in the background. This site was chosen for the littoral drift experiment described in detail in Section 6.

The surficial sediments of the coastal spits are a very uniform coarse gravel having a mean diameter of about one inch. In Photo 4, a trench that was excavated near Monument #27 shows the surface veneer of gravel quite clearly. At the time of the photo, the elevation of the spit was one foot above the prevailing still water level.

PHOTO 2. COASTAL BLUFF EROSION ON THE MAINLAND SHORE NEAR TRANSECT #5

PHOTO 3. TYPICAL GRAVEL SPIT ON MAINLAND COAST (AT TRANSECT # 27)

PHOTO 4. VERTICAL TRENCH SHOWING COMPOSITION AND DISTRIBUTION OF SEDIMENTS ON MAINLAND SPIT (TRANSECT #27)

Beneath the gravel cover lies a homogeneous mixture of sand and gravel. Wave run-up and subsequent percolation into the porous beach causes the sand to flow downward into the interstices of the underlying coarse gravel, thus creating the sand-gravel mixture observed below the beach surface at numerous locations.

The results of the recent surveys conducted on the mainland gravel spits are presented in Table 5.2. These results are summarized in the histograms that comprise Figure 5.1. Each histogram shows the number of surveyed transects (vertical scale) that experienced a given magnitude of erosion (lined area) or accretion (dotted area). Transects that changed less than two feet between July and September are judged to have undergone no change and are represented by the unshaded indicator at the midpoint of the horizontal axis. A summary is also presented adjacent to each histogram showing the number of transects experiencing erosion, accretion, and negligible change, and the average value of the change within each category.

Figure 5.1(A) shows the changes observed in the unexposed southern shoreline of the eleven coastal spits that were surveyed. Nine showed negligible change indicating that minimal wave energy is associated with the small lagoons located to the south of the spits. The average erosion computed for the south shore of all eleven spits was -0.1 feet.

The recent changes in the north shore of the coastal spits are shown in Figure 5.1(B). Of the eleven mainland spits, one experienced erosion (-5.8 feet) and five experienced accretion (average accretion = +6.5 feet). In

TABLE 5.2 : CHANGES IN MAINLAND SPITS, 1982

SUMMARY OF SURVEY DATA - MAINLAND SPITS

(ALL MEASUREMENTS EXPRESSED IN FEET)

TRANSECT	BEARING (Deg)	TRANSECT LENGTH		SOUTH WL TO MNT		MNT TO NORTH WL		ELEVATIONS		SHORELINE CHANGE AT JULY SWL DATUM	
		JULY	SEPT	JULY	SEPT	JULY	SEPT	ON MNT	SEPT SWL	SOUTH SHORELINE	NORTH SHORELINE
3	000.T	111	133	35	42	38	49	3.5	-.2	4.4 ACCRETION	9.3 ACCRETION
4	000.T	152	153	45	48	76	79	4.5	-.5	1.0 EROSION	.7 EROSION
6	355.T	112	115	32	35	56	58	3.4	-.3	.1 EROSION	.1 ACCRETION
7	000.T	127	143	51	54	55	67	4.2	-.5	.0 ACCRETION	10.7 ACCRETION
9	350.T	82	322	21	27	31	87	3.6	-1.0	.3 ACCRETION	3.3 ACCRETION
11	300.T	90	161	16	20	45	51	3.6	-.8	.2 ACCRETION	3.0 ACCRETION
15	030.T	72	111	19		35	36	4.3	-.7	.1 EROSION	2.0 EROSION
25	003.T	176	211	46	47	119	128	2.8	-.6	2.2 EROSION	6.0 ACCRETION
26	000.T	130	161	50	61	65	72	1.6	-.7	1.0 EROSION	.6 EROSION
27	000.T	68	81	22	25	34	34	3.0	-.7	1.1 EROSION	5.0 EROSION
28	344.T	100	102	27	29	55	57	3.4	-.7	.2 EROSION	1.3 EROSION

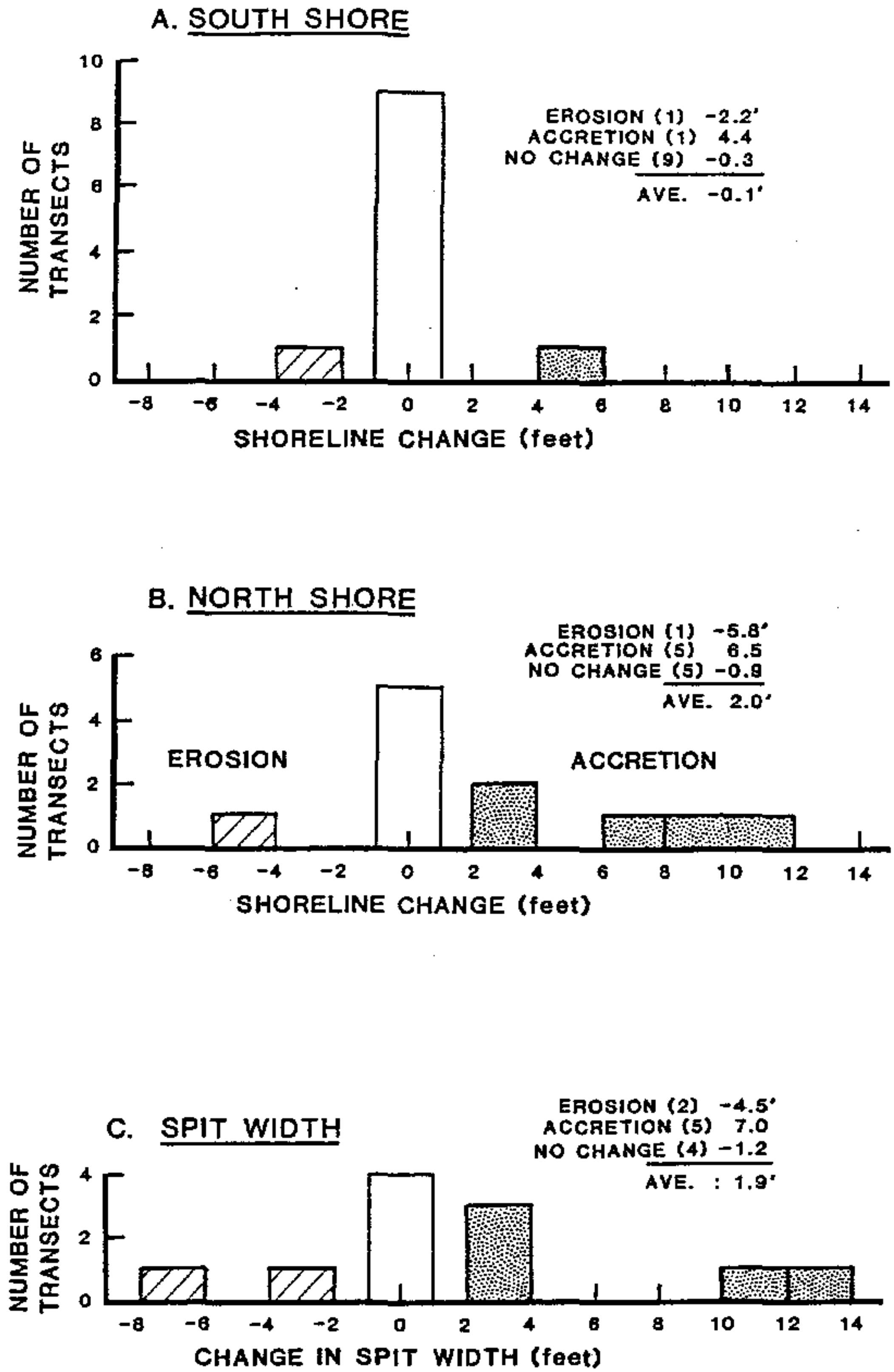


FIGURE 5.1 : SHORELINE CHANGE HISTOGRAM, MAINLAND SPITS, 1982

addition, five transects experienced negligible change (less than two feet of measured change) that averaged 0.9 feet of erosion.

By combining the results of the data measured for the north and south shores of the surveyed spits, a histogram can be developed to show the changes in total spit width. As shown in Figure 5.1(C), the two spit transects that narrowed had an average loss of 4.5 feet. For the five spits that widened, the average accretion was 7.0 feet, while four spits showed negligible change. For all the coastal spits, the average change was 1.9 feet of accretion.

While the results show that the mainland spits of the study region experienced both erosion and accretion during the recent summer, spit widening appears to be dominant at this time. It is quite clear that the south sides of mainland spits were quite static. Because wave overtopping is the major mechanism of shoreline change on the back side of the spits, this lack of southern shoreline change implies that very few, if any, spits were overtopped by waves during periods of high water level this past summer.

5.1.3 Low Mainland Shore

Twenty-four transects remain on the mainland coast when one eliminates the previously discussed coastal bluffs and spits. Table 5.3 lists the survey specifics of these low-lying profiles. A histogram illustrating the range of shoreline changes is presented as Figure 5.2. The data shows that the majority (71%) of the transects of this group exhibited negligible shoreline change which emphasizes the stability that has been recently observed. Six of the 24 transects experienced erosion, averaging -3.9 feet. The

TABLE 5.3 : CHANGES IN LOW MAINLAND SHORE, 1982

SUMMARY OF SURVEY DATA - LOW MAINLAND SHORE

(ALL MEASUREMENTS EXPRESSED IN FEET)

TRANSECT	BEARING (Deg)	TRANSECT LENGTH		SOUTH WL TO MNT		MNT TO NORTH WL		ELEVATIONS		SHORELINE CHANGE AT JULY SWL DATUM	
		JULY	SEPT	JULY	SEPT	JULY	SEPT	ON MNT	SEPT SWL	SOUTH SHORELINE	NORTH SHORELINE
1	035.T	146	142			128	128	4.3	-.1		.2 EROSION
8	010.T	57	80			47	54	3.3	-.7		2.7 EROSION
10	334.T	160	195			144	151	4.7	-1.1		.1 ACCRETION
12	000.T	125	159			113	119	7.4	-1.1		6.2 EROSION
13	000.T	115	180			100	114	5.0	-.8		4.0 ACCRETION
14	020.T	73	82			63	64	3.4	-.5		2.0 EROSION
16	040.T	93	135			81	88	3.1	-.6		.4 EROSION
17	343.T	79	262			51	56	3.6	-.5		1.2 EROSION
18	040.T	84	106			70	71	3.7	-.1		.4 ACCRETION
19	036.T	106	139			78	79	4.1	-.3		3.0 EROSION
20	352.T	197	243			172	177	3.9	-.2		6.8 EROSION
21	300.T	92	134			53	54	3.2	-.2		0.0 ACCRETION
22	350.T	101	205			78	77	5.2	-.2		2.2 EROSION
23	000.T	126	195			103	118	4.2	-.3		2.0 ACCRETION
24	000.T	172	224			108	145	2.1	-.7		.4 EROSION
29	019.T	115	120			82	87	3.1	-.6		.4 EROSION
30	045.T	91	93			78	80	5.8	-.6		1.7 EROSION
31	000.T	101	105			87	92	7.8	-.6		1.5 ACCRETION
32	000.T	130	141			109	115	7.8	-.5		.4 ACCRETION
33	008.T	160	168			141	145	3.0	-.5		1.0 EROSION
35	002.T	145	170			114	116	6.7	-.6		1.9 EROSION
36	062.T	158	162			142	145	3.2	-.5		.5 EROSION
37	066.T	122	126			105	112	7.5	-.5		1.6 ACCRETION
38	028.T	195	243			129	161	7.0	-.7		2.2 EROSION

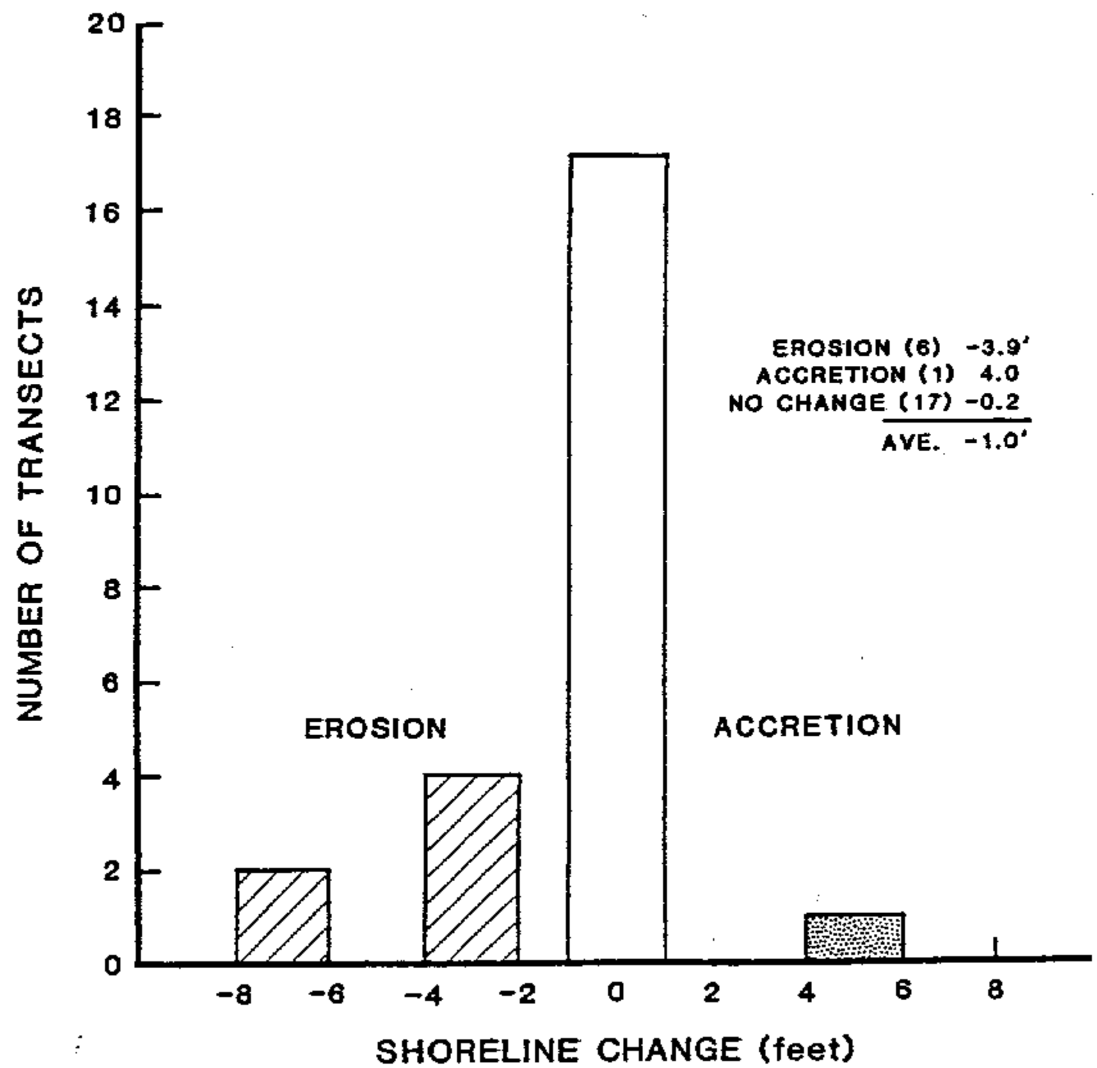


FIGURE 5.2 : SHORELINE CHANGE HISTOGRAM, LOW MAINLAND SHORE, 1982

only significant accretion measured was +4.0 feet at Transect #13, located on Pt. Hopson. The overall average change in these 24 transects was erosion of -1.0 foot.

The most recent findings underscore the generally held view that the mainland shore is relatively stable. Although there were several transects that experienced large shoreline fluctuations, the majority showed changes of less than two feet, implying general overall stability.

Figure 5.3 shows the change in shore position for all the mainland shore transects, represented by Monuments #1 - 38 (Ref. Figure 4.6). The areas of maximum accretion are at Transects #3 (a gravel spit), #7 (Pt. Hopson), and #25 (Pt. Thomson). All of these transects are located on sand spits, the latter two at the terminal ends of spits where sediment accumulation would be expected.

The sites of major erosion are Transects #12, 20, and 27. Both Transects #20 and #27 are located to the south of Mary Sachs Entrance, the only area within the study region that is not protected from northeast wave action by the offshore islands. With the exception of Transect #25 (an area of deposition at the end of Pt. Thomson), the reach of coast that is opposite Mary Sachs Entrance (Transects #18-28) experienced predominant erosion. This region of shore, by virtue of the lack of offshore island protection, is subject to the highest degree of easterly wave impact in the mainland portion of the study area.

The low-lying mainland shore is classified as a "chenier" beach formation, in which the sand and gravel beach sediments exist as a thin lens above a dense tundra foundation (King, 1961). During periods of strong westerly

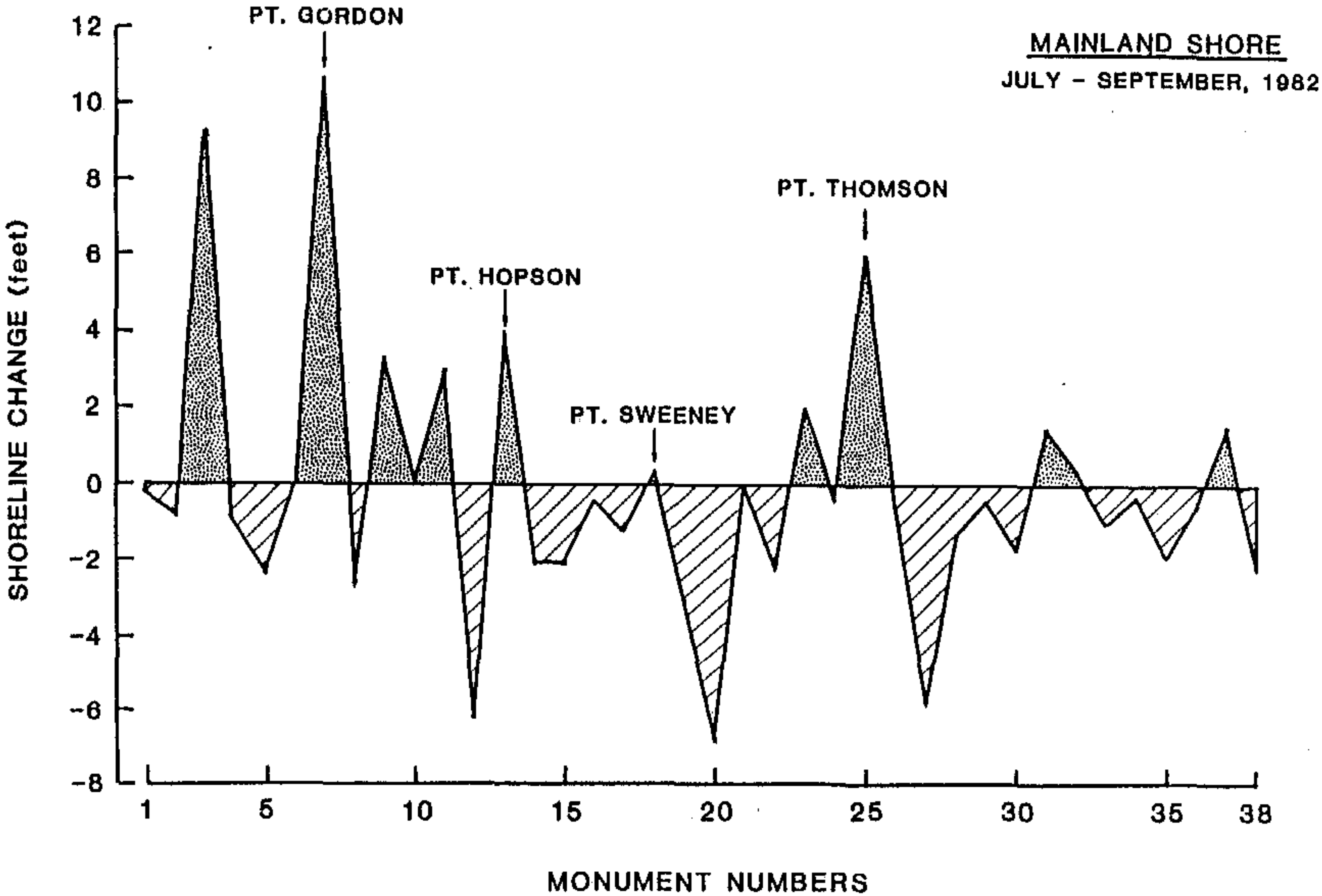


FIGURE 5.3 : CHANGES IN MAINLAND SHORE POSITION, 1982

winds, the water level rises, allowing the waves to push the beach sediments further and higher on the tundra base. In many areas of the mainland shore where beach sediments are sparse, the tundra has been exposed by wave energy at the existing water line, as shown in Photo 5. At other coastal transects exhibiting a larger beach volume, a steep storm scarp exists which was formed in the chenier beach during a period of high wave activity. Photo 6, taken near Transect #36, is an example of a typical wave-generated scarp.

Trenching of the mainland beach sediments was found to expose the tundra foundation at depth, as shown in Photo 7. Successive trenching along a profile allowed estimation of the beach sediment volume.

At Transect #18, the total volume of beach sediment was computed to be seven cubic yards per lineal foot of shoreline, as shown in Figure 5.4. This small volume of beach sediment is typical of the chenier beach environment within the study area and renders this formation highly sensitive to disruption in the supply of littoral drift.

At most of the surveyed transects, the mainland beach sediments extend offshore for a very short distnce. No sand bars exist along the mainland shore due to the sparseness of the necessary sediments. In the shallow nearshore, at the toe of the chenier beach, eroding tundra forms a highly organic, dense mud. The dense, vegetative matric that comprises the tundra resists erosion from the rather low, ambient wave energy. This results in the rather stable condition of the mainland shore that was documented previously.

PHOTO 5. MAINLAND BEACH OVERLYING TUNDRA BASE. NOTE TUNDRA EXPOSURE NEAR WATER LEVEL.

PHOTO 6. TYPICAL WAVE-GENERATED COASTAL SCARP NEAR TRANSECT #36, MAINLAND COAST.

PHOTO 7 VERTICAL TRENCH SHOWING SEDIMENT DISTRIBUTION OVER TUNDRA BASE

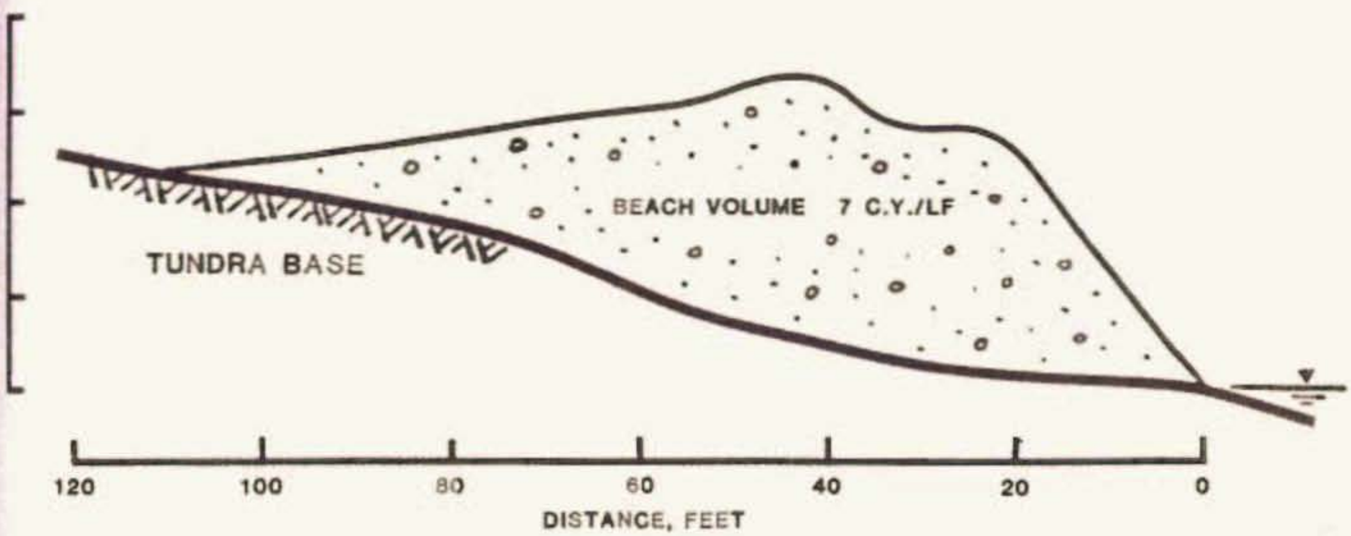


FIGURE 5.4 : CROSS-SECTION OF CHENIER BEACH, TRANSECT #18

The distinct and sudden boundary between the beach sediments and the underlying tundra at the back of the beach is quite dramatic. Photo 8 illustrates the complete and well-defined coverage of the beach veneer over the tundra base. It is believed that this is due to the stability of the sediments at this elevation which are subject to waves and currents only during the rare, extreme storm events. During the interim calm weather periods, the vegetation existing on the tundra can flourish, thus, creating the very stable and distinct interface that is evident in the photo.

An aerial photo taken above the Pt. Thomson spit and adjacent shore is shown in Figure 5.5. The chenier beach that exists atop the mainland tundra appears as a sinuous white line near the land-water interface. Along the coast shown in this photo, the chenier beach is located slightly inshore of the tundra shore, implying that the beach sediments in this sheltered area are active only during times of major storm wave activity.

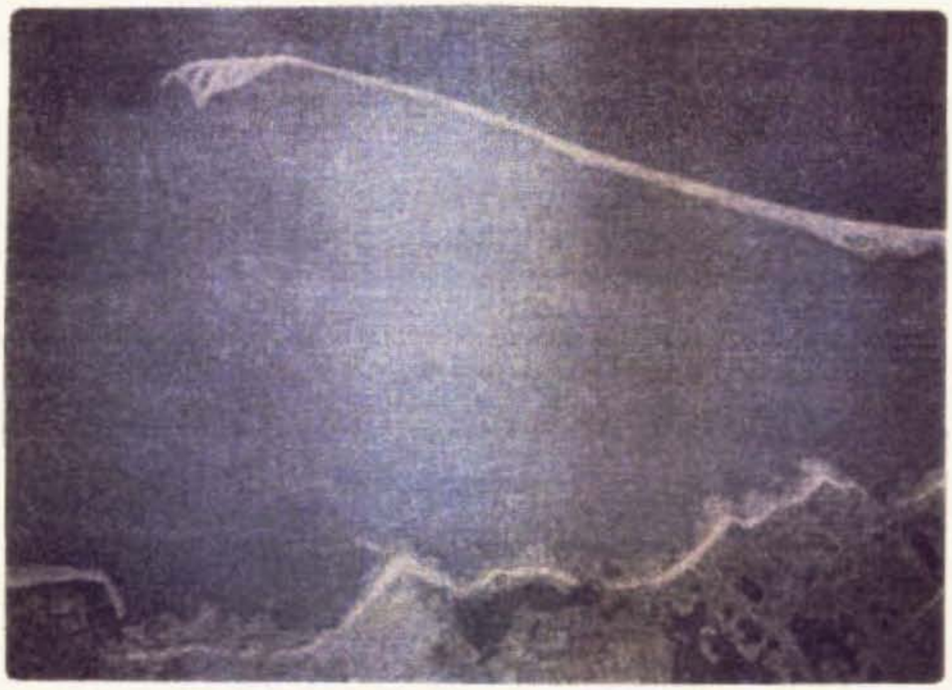
5.2 Areas of Significant Shoreline Change

The most active shoreline areas in the study zone are the bluffs of Flaxman Island and along the low-lying barrier islands. These two zones are related in that the eroding bluffs of Flaxman Island serve as the source of the sediments that nourish the down-drift barrier islands.

5.2.1 Flaxman Island Bluffs

Flaxman Island has been noted to experience a high-level of bluff erosion dating back to the reports of the earliest explorers of the region. The high, flat island form is shown in Photo 9, taken in early July, 1982. The

PHOTO 8. VIEW OF THE BACK OF MAINLAND "CHENIER" BEACH SHOWING DISTINCT SEPARATION BETWEEN BEACH AND TUNDRA



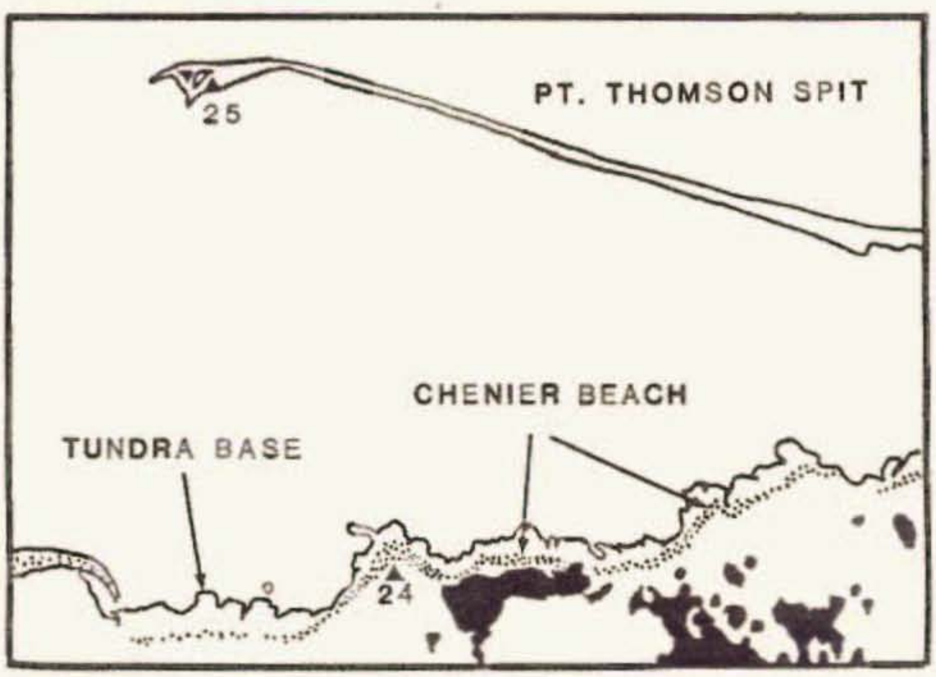


FIGURE 5.5 : AERIAL VIEW OF CHENIER BEACH

eroding bluff along the northern shore is shown in Photo 10 to be in contact with a protective ice foot at the bluff base. Until this ice foot melts or is dislodged, incoming wave energy cannot affect the stability of the bluff. A second view of the eroding bluff (Photo 11) shows a thick ice wedge that exists below the surface veneer of tundra. Also noteworthy is the variability of eroded sediment size, as illustrated by the large boulder that is on the verge of falling out of the bluff face. The unusual lithology of the Flaxman Island formation has been described previously in Section 2.1.

The northern bluffs of Flaxman Island are characterized by the massive blocks of tundra that are slumping downslope. Unlike beach erosion that can progress in small increments, much of the bluff erosion witnessed on Flaxman Island occurred in large sections measuring approximately fifty feet in length and 10-20 feet in the offshore direction. Photo 12 illustrates an example of an eroded bluff portion of this size. This eroded block of tundra may serve to protect and insulate the remaining bluff face, thereby slowing the future bluff erosion at this location until the block erodes.

Table 5.4 documents the changes noted between surveys at the transects located on the high Flaxman Island bluffs. Disregarding the transect having southwesterly wave exposure (Transect #45), the bluff recession averaged 10.7 feet during the July-September comparison period.

A comparison of the Flaxman Island shoreline of 1982 with that of 1955 (from the NOAA chart) can be used to determine the expected annual volume of the material eroded from the northern bluff. In Figure 5.6, the change in bluff

PHOTO 9. AERIAL VIEW, EAST END OF FLAXMAN ISLAND

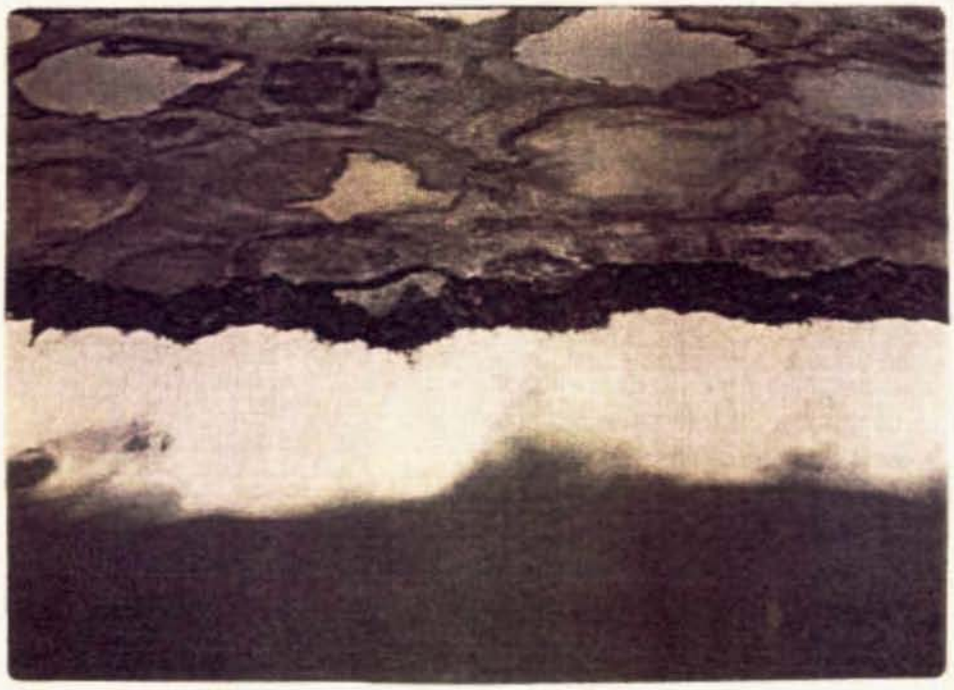


PHOTO 10. AERIAL VIEW OF ERODING NORTHERN BLUFF, FLAXMAN ISLAND, JULY, 1982. NOTE ICE ATTACHED TO BLUFF TOE

PHOTO 11. ERODING BLUFF ON FLAXMAN ISLAND SHOWING UNDERLYING ICE LENS AND LARGE BOULDER

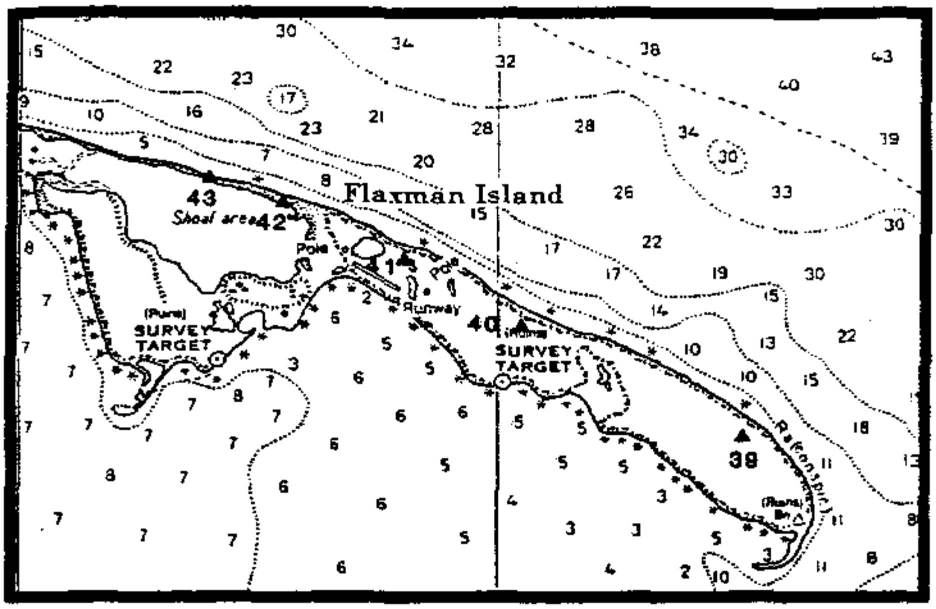
PHOTO 12. TYPICAL BLUFF EROSION, NORTHERN SHORE OF FLAXMAN ISLAND

TABLE 5.4 : CHANGES IN FLAXMAN ISLAND BLUFFS, 1982

SUMMARY OF SURVEY DATA - FLAXMAN ISL BLUFF

(ALL MEASUREMENTS EXPRESSED IN FEET)

TRANSECT	BEARING (Deg)	TRANSECT LENGTH		SOUTH WL TO MNT		MNT TO NORTH WL		ELEVATIONS		SHORELINE CHANGE AT JULY SWL DATUM	
		JULY	SEPT	JULY	SEPT	JULY	SEPT	ON MNT	SEPT SWL	SOUTH SHORELINE	NORTH SHORELINE
39	034.T	144	161			108	108	20.3	0.0		5.2 EROSION (BLUFF)
40	023.T	177	186			120	102	16.4	0.0		20.5 EROSION (BLUFF)
41	029.T	107	128			107	111	13.9	0.0		6.5 EROSION (BLUFF)
45	080.T	115	134			69	68	8.0	-.3		2.2 EROSION
											0.0 EROSION (BLUFF)



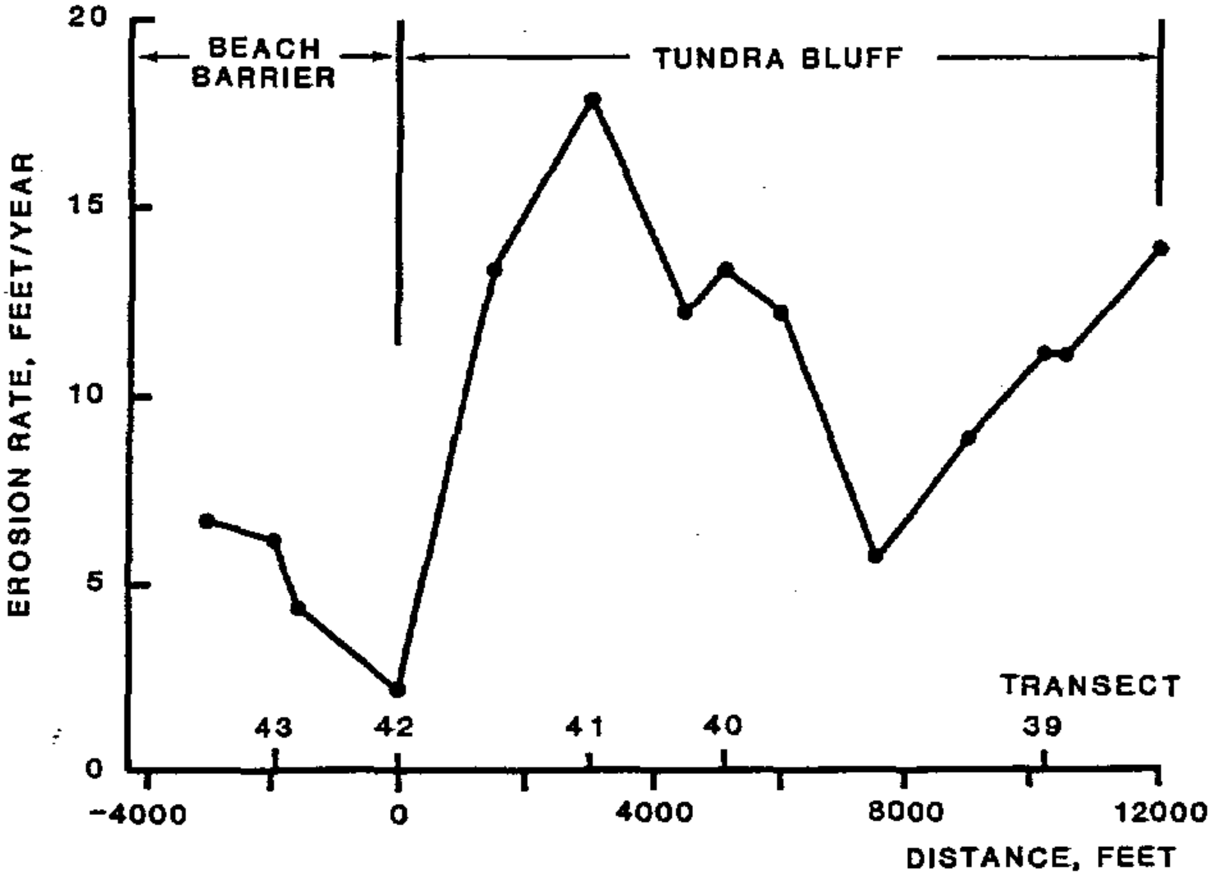


FIGURE 5.6 : FLAXMAN ISLAND EROSION, 1955–1982

position for the two surveys is shown. Erosion of the northern bluff has averaged 12 feet/year during the 32-year period of comparison, however, the magnitude of the erosion measured in any given year could vary considerably from this figure. The relatively higher erosion rates experienced on the bluffs are in contrast to the lower rates seen on the adjoining beaches to the west. Given the historical measurement of bluff retreat (Figure 5.6) and knowing bluff elevations as measured by the recent survey, an average annual eroded bluff volume of 70,000 cubic yards has been computed.

Because a large portion of the bluff that erodes is ice, or fine-grained silts and clays that do not remain in the beach zone, the gross eroded volume must be reduced to determine the volume of sands and gravels derived from the bluff that add to the downcoast beach volume. Estimating a total sand and gravel content of 20% for the eroding bluff material, the net volume is reduced to 15,000 cubic yards of beach sediments annually. By virtue of this sediment contribution, Flaxman Island can be considered to be a sacrificial source of beach material which maintains the barrier island chain located directly downdrift.

The on-going bluff erosion has greatly diminished the size of Flaxman Island over the past 150 years. Future erosion, if unchanged from the rates of the recent past, will lead to total breaching of the bluffed portion of the island within the next 100 to 200 years. As this source of barrier island sediments diminishes, the islands will diminish in size and volume. While this could be a slow process, the persistent ice and wave forces will lead invariably to reduction of barrier island size as the source of nourishment grows smaller.

5.2.2 Barrier Islands

Since 1955, the barrier islands have experienced a high degree of change in both shape and location. These islands show a degree of instability that, along with the Flaxman bluffs, yields the highest rates of coastal change in the study area. During the recent summer, erosion predominated along the shores of the barrier islands, as evidenced by the data presented in Table 5.5 and Figure 5.7. The changes associated with the positions of the southern shores are shown in Figure 5.7(A). Of the twenty-five island transects, ten experienced negligible movement of the southern shore. An equal number of the southern transects eroded (averaging -4.8 feet) while the remaining five transects experienced accretion to the south (average accretion = +5.3 feet). The average change of all of the southern transects was erosion of 0.9 feet.

The general trend of erosion identified on the south shore of the barrier islands intensified on the northern shore. This was expected due to the greater exposure to wave and ice forces on the north sides of the islands. Figure 5.7(B) shows that shoreline changes experienced on the north shores varied from nine feet of accretion to nearly 25 feet of erosion. At ten of the 25 north transects, erosion occurred (average loss = 11.0 feet), while at nine locations, northern shore accreted (average growth = +5.7 feet). At six sites, negligible change occurred. For all the northern transects, the average change was erosion of 2.4 feet.

TABLE 5.5 : BARRIER ISLAND SHORELINE CHANGES, 1982

SUMMARY OF SURVEY DATA - BARRIER ISLANDS

(ALL MEASUREMENTS EXPRESSED IN FEET)

TRANSECT	BEARING (Deg)	TRANSECT LENGTH		SOUTH WL TO MNT		MNT TO NORTH WL		ELEVATIONS		SHORELINE CHANGE AT JULY SWL DATUM	
		JULY	SEPT	JULY	SEPT	JULY	SEPT	ON MNT	SEPT SWL	SOUTH SHORELINE	NORTH SHORELINE
42	018.T	207	223	78	80	101	106	4.0	-.2	1.2 ACCRETION	3.4 ACCRETION
43	014.T	171	172	63	68	71	72	3.7	-.3	3.0 ACCRETION	.9 EROSION
44	033.T	261	296	59	60	05	85	2.8	-.2	.5 EROSION	1.6 EROSION
46	000.T	214	250	41	58	146	159	1.1	-.7	8.7 ACCRETION	4.8 ACCRETION
47	020.T	151	193	42	53	61	77	2.0	-.9	5.5 EROSION	8.3 ACCRETION
48	026.T	177	272	64	89	64	76	2.8	-1.0	3.5 EROSION	7.6 ACCRETION
49	000.T	687	723	375	384	281	292	3.9	-1.5	3.6 EROSION	9.6 EROSION
50	356.T	442	678	196	443	178	195	2.2	-1.3	4.2 EROSION	16.6 EROSION
51	358.T	474	523	322	342	110	135	2.7	-1.7	5.9 EROSION	9.0 ACCRETION
52	340.T	523	1409	225	1011	263	294	1.0	-1.9	.0 ACCRETION	5.1 EROSION
53	026.T	129	509	44	296	49	51	2.3	-.5	5.6 EROSION	2.6 EROSION
54	006.T	476	514	360	372	79	94	4.1	-1.7	1.2 EROSION	2.4 ACCRETION
55	020.T	191	334	96	179	55	69	2.7	-1.5	.4 ACCRETION	.1 EROSION
56	015.T	214	248	76	89	103	116	2.7	-1.5	.2 EROSION	.2 EROSION
57	000.T	171	194	68	78	69	86	5.7	-1.3	.3 ACCRETION	7.4 ACCRETION
58	000.T	317	336	137	147	138	150	5.2	-1.7	1.5 EROSION	.3 ACCRETION
59	340.T	388	424	205	217	127	150	2.4	-1.7	2.8 EROSION	8.0 EROSION
60	332.T	445	485	310	320	92	120	2.3	-1.7	2.8 EROSION	22.0 EROSION
61	040.T	92	236	21	97	32	55	1.7	-1.6	8.9 EROSION	5.5 EROSION
62	012.T	145	213	29	63	66	77	3.3	-1.7	1.4 ACCRETION	3.3 ACCRETION
63	015.T	141	289	61	90	52	68	3.3	-1.5	6.0 ACCRETION	4.7 ACCRETION
64	008.T	435	497	48	65	352	369	2.5	-1.5	4.5 ACCRETION	24.7 EROSION
65	012.T	273	455	132	162	92	186	4.2	-1.7	4.9 EROSION	5.0 EROSION
66	000.T	190	207	80	96	69	81	3.4	-1.5	4.3 ACCRETION	1.0 ACCRETION
67	008.T	252	477	42	245	152	171	2.7	-1.7	.2 EROSION	10.2 EROSION

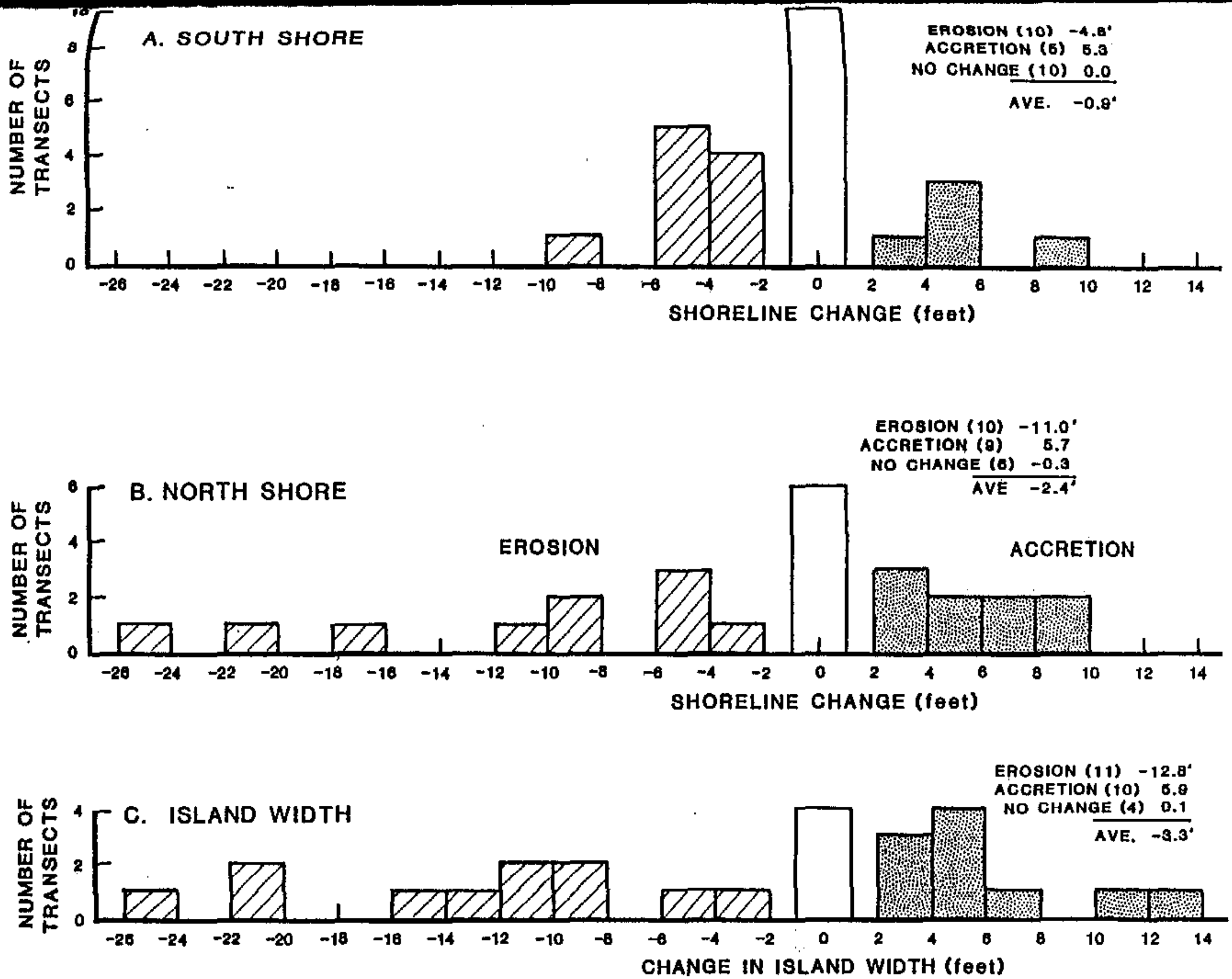


FIGURE 5.7 : SHORELINE CHANGE HISTOGRAM, BARRIER ISLANDS, 1982

Combining the results of the north and south shore changes, the total changes in island width at each transect can be presented in Figure 5.7(C). As one would expect from the data presented previously, the predominant trend during the recent survey period was one of diminishing island width. Only four of the twenty-five island transects experienced negligible change. Eleven experienced erosion (average loss in width = 12.8 feet) while ten transects increased in width (average gain = 5.9 feet). The average change in island width for all transects was erosion of 3.3 feet.

While it is difficult to attribute a great deal of significance to shoreline comparisons that span only a six week period, the high degree of shoreline fluctuation on the barrier islands as well as the general trend towards erosion is consistent with previous investigators (Wiseman, et al., 1973).

Figure 5.8 summarizes the recent changes in shoreline position associated with the entire barrier island chain under study, bounded by the east end of the Flaxman Island spit (Transect #42) and the west end of Alaska Island (Transect #67). On the northern shores, moderate accretion (4-10 feet) occurred at four distinct areas of the central portions of each of the island complexes. Erosion of large magnitude (15-25 feet) occurred near the center of Mary Sachs and Alaska Islands, and on the west end of Duchess Island.

Along the southern shore, less dramatic changes occurred. Erosion appears to dominate the south shore of Mary Sachs Island. On Duchess-North Star Island, virtually

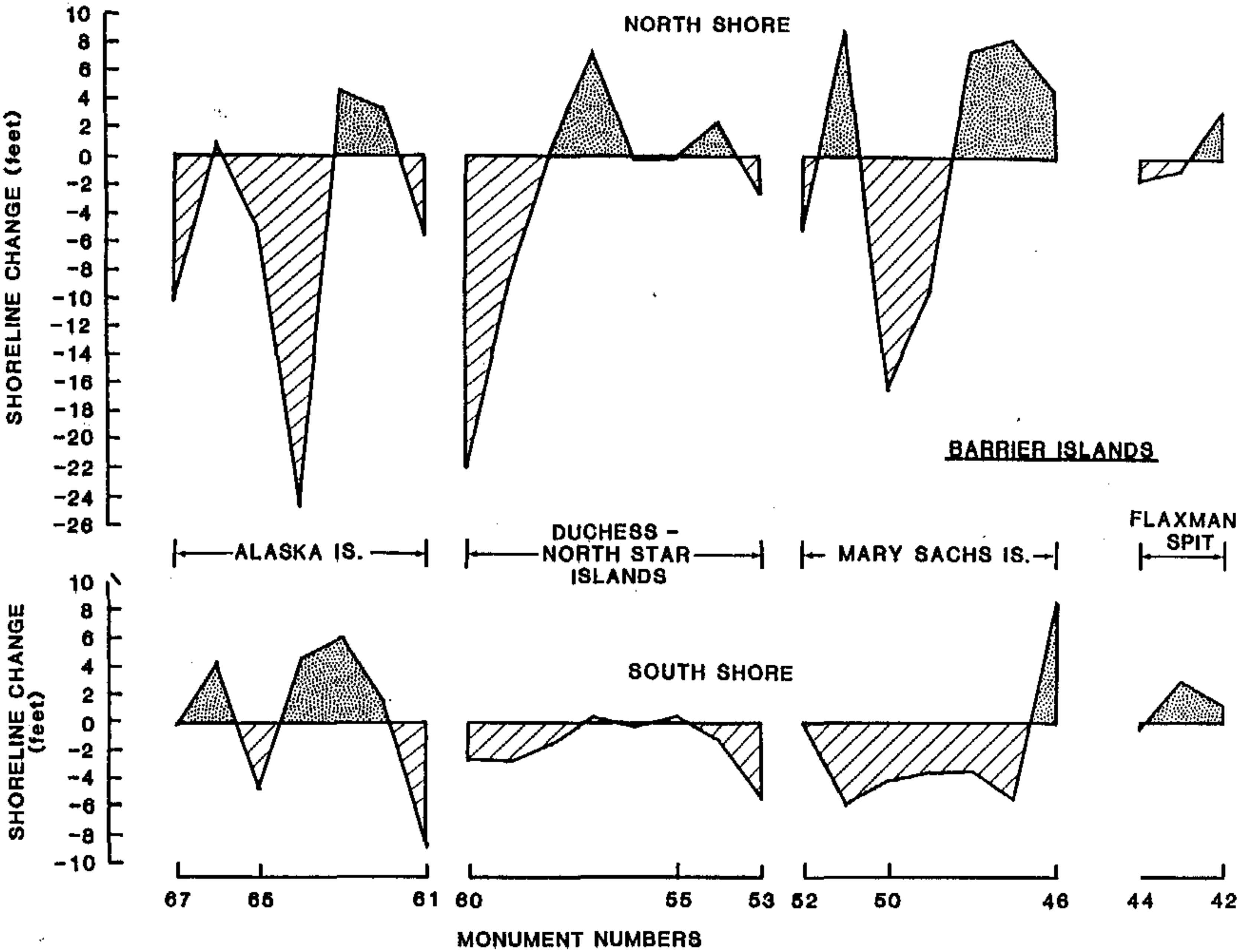


FIGURE 5.8 : BARRIER ISLAND SHORELINE CHANGES, 1982

no changes have occurred along the central island south shore. On Alaska Island, the south shore fluctuates between mild erosion and accretion.

It is significant to note in Figure 5.8 that the ends of islands adjacent to major inlets are showing a recent erosional trend. The trend towards island erosion at these inlets is caused by a number of factors which include high speed currents generated by tides and meteorological events and a high degree of wave-induced sediment transport. The sediments that migrate off the island end and into the inlets cannot be recovered in total when the wind and wave conditions reverse.

The very small inlet that has formed between Flaxman and Mary Sachs Islands has not caused erosion on the adjoining island ends (see Figure 5.8). This narrow, shallow feature is relatively protected and may be subject to predominant sediment deposition at the present time.

During the summer surveys, major changes were observed at several survey transects along the barrier island chain. Photo 13 shows a view of Monument #61, located just east of the Alaska Island exploration pad, at the time of the initial survey target on July 25, 1982. Following a strong westerly storm on the following day, the target was observed to be partially buried by sand that had been transported onto the target during the storm (Photo 14). At the time of the September survey, the target had been buried to an even greater extent, as shown in Photo 15, by a subsequent westerly storm event or events. The depth of total burial was about six inches, as shown in the plot of comparative surveys, Figure 5.9. During the July-September period, the sediment that buried the target was apparently derived from

PHOTO 13. TRANSECT #61, EAST END OF ALASKA ISLAND, JULY 25, 1982. SOHIO'S EXPLORATION PAD IS SEEN IN THE BACKGROUND

PHOTO 14. AERIAL VIEW SHOWING PARTIAL BURIAL OF TARGET AT TRANSECT #61 IMMEDIATELY FOLLOWING WESTERLY STORM OF JULY 26, 1982

PHOTO 15. TARGET BURIAL AT TRANSECT #61, SEPTEMBER 11, 1982

PHOTO 16. PARTIAL TARGET BURIAL CAUSED BY WESTERLY STORM EVENTS AT TRANSECT #53, EAST END OF NORTH STAR ISLAND, SEPTEMBER 11, 1982

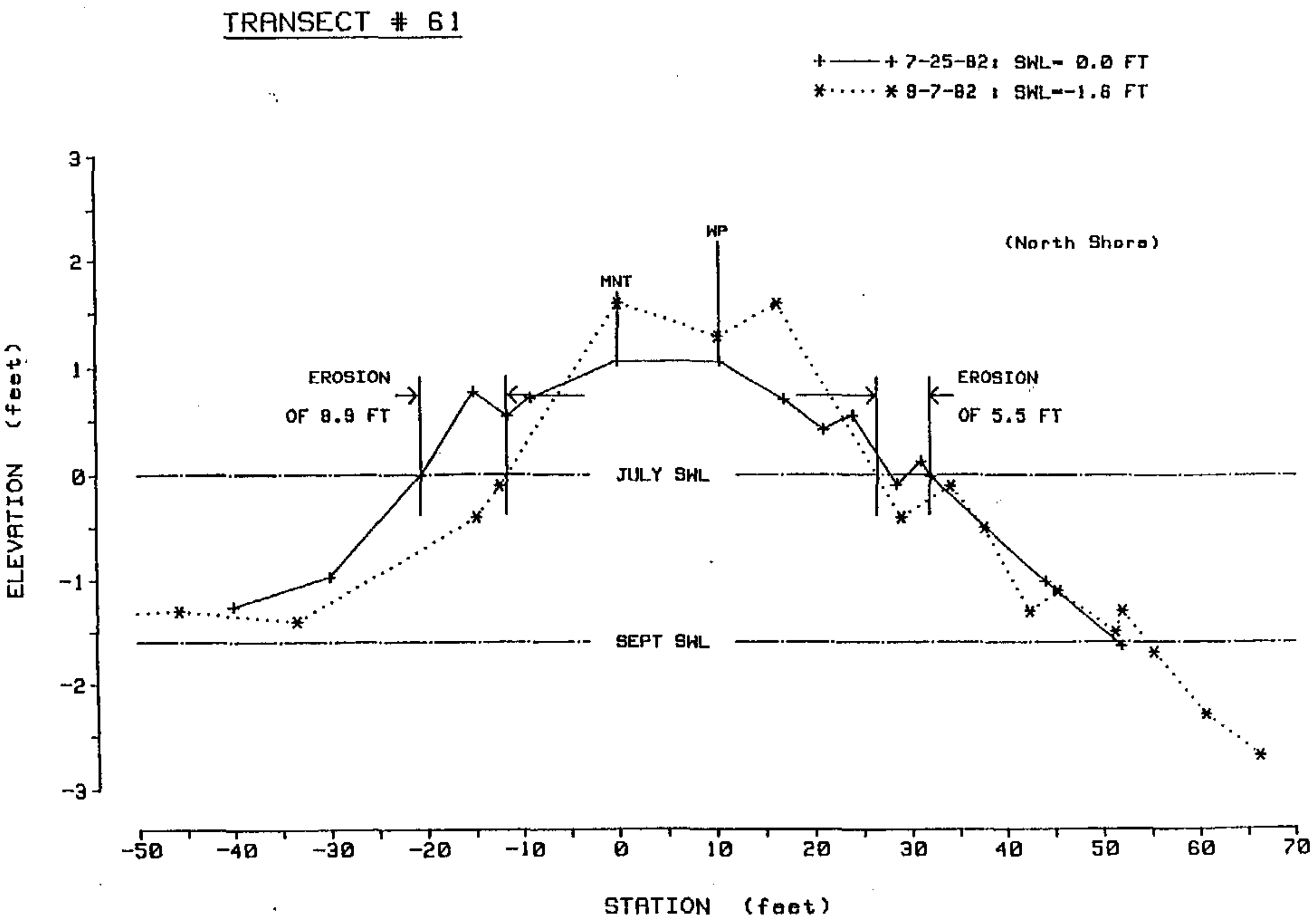


FIGURE 5.9 : BARRIER ISLAND EROSION AND DEPOSITION, TRANSECT #61

erosion of the southern shore. The deposition of the eroded sediment on the island surface occurred during periods of wind-induced storm surge caused by westerly storm events.

A similar depositional event occurred on North Star Island at Monument #53, as shown in Photo 16. A layer of sediment (10 inches thick) is seen to overlie the target at this location. These two cases of major sediment deposition atop the island surface occurred at sites of similar exposure to westerly storm events. Monument #61 is located on the southwest-facing shore of Alaska Island, while Monument #53 has the identical orientation on the east end of North Star Island.

5.3 Island Migration Trends

Changes in the overall form and location of the low-lying barrier islands are occurring constantly. The results of the 1982 survey allows the long-term comparison of island configuration within the Maguire group shown in Figure 5.10. The major observations of note are the changes of location and form of the various inlets, the dynamic nature that is evident at the island ends adjacent to these inlets, and the general westward movement of the islands.

In 1955, Flaxman Island and Mary Sachs Island were connected by a thin strip of sediment. Today, a narrow, shoal inlet exists, as illustrated in Photo 17. The very shallow nature of this inlet, in addition to the sediment accumulation that is active here (See Figure 5.8), indicates that this inlet may be in the process of filling, thereby connecting the two islands once again.

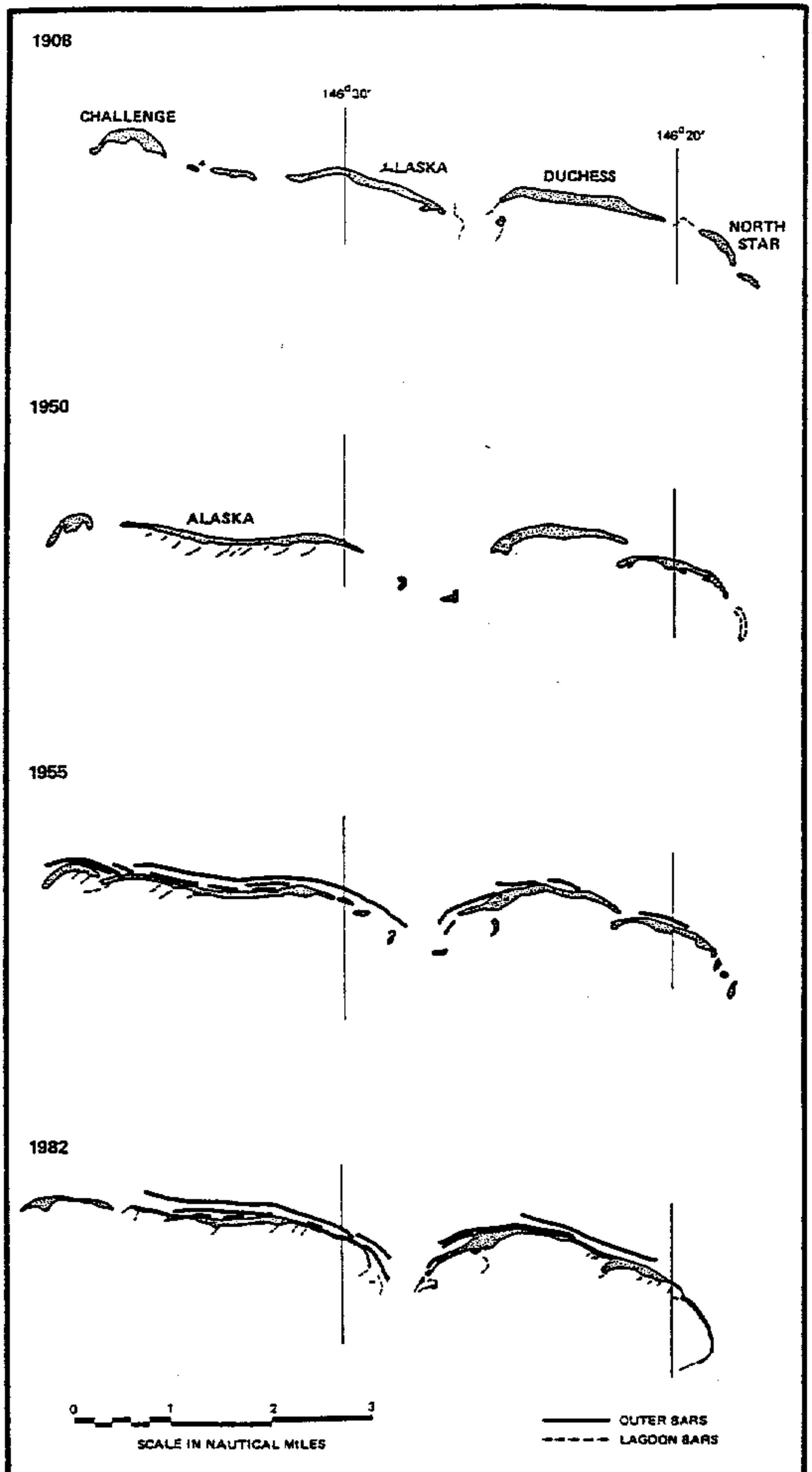


FIGURE 5.10 : MAGUIRE ISLAND MIGRATION, 1908–1982

PHOTO 17. OVERHEAD VIEW OF INLET RECENTLY FORMED BETWEEN FLAXMAN AND MARY SACHS ISLANDS. INLET IS 750 FEET WIDE AND TWO TO FOUR FEET DEEP

A major island breach existed in 1955 between North Star and Duchess Islands. On the NOAA chart, an inlet depth of seven feet was measured in 1950. At the present time, the inlet has been filled and a continuous island exists in this area, located just west of the North Star exploration pad. A photographic comparison has been achieved by presenting a 1982 survey photo and one collected by Dr. Andrew Short in 1972. In Photo 18, a view of the inlet between Duchess and North Star Island is shown in 1972. Breaking waves can be seen within the inlet. In July, 1982, Photo 19 was taken from approximately the same location showing a thin sediment strip that presently exists over the former inlet.

Also evident in these photos is the location of Exxon's North Star drilling pad relative to the site of the inlet, and the similar shape of the island shoreline in both 1972 and at the present. The recent filling of the inlet, documented in these photographs, is a process that is common to barrier island environments.

Figure 5.11 shows a conceptual view of inlet formation and filling. A large storm event can cause the initial breach formation which is followed by initial inlet deepening by tidal currents (Stage 1). With time, however, the persistent easterly wind and waves transport sediment in a westward direction, thereby reconnecting the two island segments with a thin strip of sand and gravel (Stage 2). As this sediment body continues to be nourished by the updrift sediment supply, the filling of the inlet proceeds (Stage 3). This total process can occur within a span of several years, as witnessed during the 1979-1981 period on No Name Island (Gadd, et al., 1982).

PHOTO 18. AERIAL VIEW OF INLET BETWEEN NORTH STAR AND DUCHESS ISLAND, AUGUST, 1972 (SOURCE: DR. ANDREW SHORT)

PHOTO 19. VIEW OF FILLED INLET THAT NOW CONNECTS DUCHESS AND NORTH STAR ISLANDS, JULY, 1982. EXXON'S NORTH STAR DRILLING PAD IS SEEN IN THE BACKGROUND

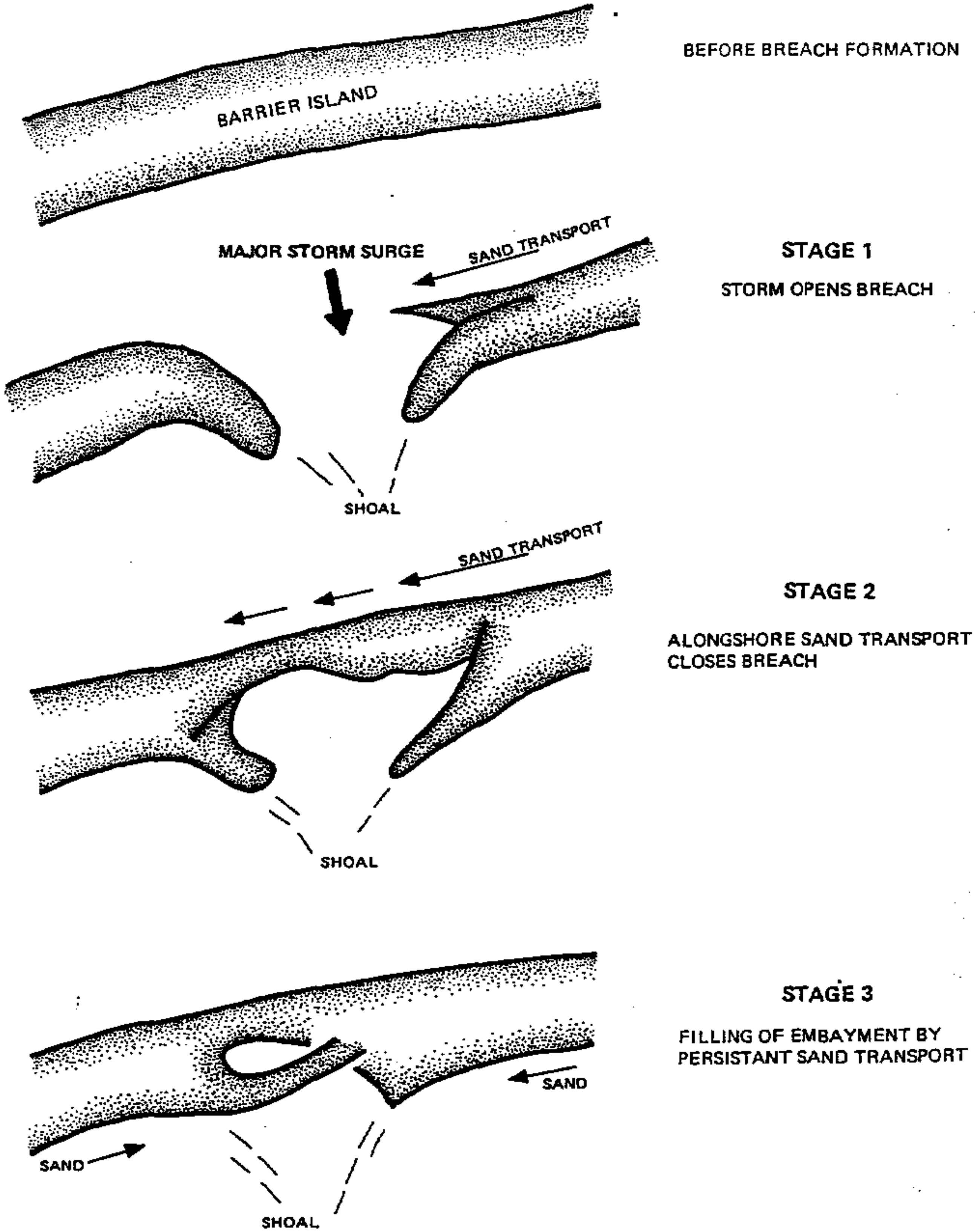


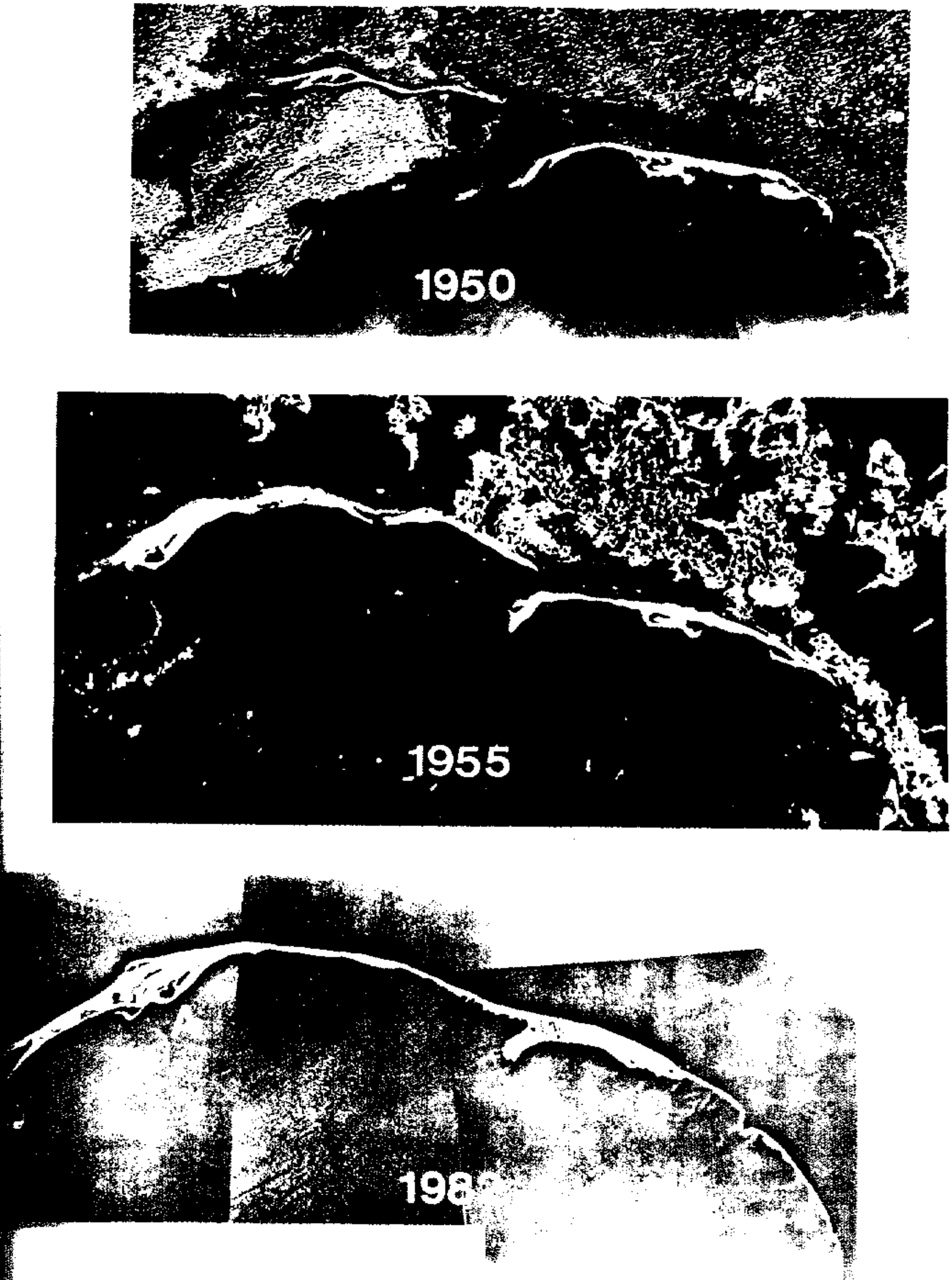
FIGURE 5.11 : BARRIER ISLAND INLET FORMATION

Another historical photo comparison is shown in Figure 5.12, illustrating the changes that have occurred at the Duchess-North Star complex since 1950. In the bottom photo, showing the present condition, three coastal features are noted. Feature "A" is a large lobe of sediment that was once the western end of Duchess Island, as seen in 1950. The growth of the sand spit towards the west in the past 32 years has advanced the west end of the island a total of 4500 feet, an average annual rate of 140 feet/year.

The second feature noted on the 1982 photo, designated "B", is the site of the former inlet that separated North Star and Duchess Islands. Exxon's North Star exploration pad is located just east of this location. Sand spits and striations are seen in the 1982 photo on the south side of the island at the former inlet location, implying that this area is still subject to wave overtopping during periods of high water levels. The comparative photos of the inlet (Photos 17 and 18) show that the inlet filled within the past 10 years, although it is seen in Figure 5.12 that the width of the inlet was continuously decreasing during the 1950-1955 period.

The feature designated "C" in the photo is a broad expanse of sediment that is now diminished from the size it exhibited in the 1950's. In the 1950 and 1955 photos, the intricate structure of this feature remained relatively unchanged, as did the structure of feature "A" during the 1950-1982 period.

Both of these features (A and C) are former western island ends which have been isolated from the active northern shore by continual sediment accretion and the resulting island widening at these locations. The continual



12 : PROGRESSIVE CHANGE OF DUCHESS-NORTH STAR ISLAND, 1950-1982

westward sediment transport which predominates here has elongated the island to the west, thereby preserving these features on the southern shores of the islands.

TABLE 5.6

PT. THOMSON PROJECT
ISLAND MIGRATION RATES, 1955-1982

ISLAND	WEST END	EAST END
Challenge	42 ft/year (west)	39 ft/year (east)
Alaska	68 ft/year (west)	90 ft/year (southeast)
Duchess	96 ft/year (southeast)	-----
North Star	-----	151 ft/year (south)
Mary Sachs	83 ft/year (southwest)	-----
AVERAGE:	72 ft/year	93 ft/year

The long-term rates of island migration between 1955 and 1982 have been measured and are presented in Table 5.6. The exact locations of the island ends were determined in July using the helicopter-borne electronic navigation system. These survey methods were described previously in Section 3.1 for the determination of the individual transect locations. The position of the island ends were reduced to latitude/longitude for direct comparison with the charted positions of 1955 which are documented on NOAA chart #16045. The average rate of westward island migration during this period was 72 feet/year which agrees very well with the data derived by Wiseman, et al., (1973) for the 1908-1955 period. The expected westerly island migration is noted on the ends of Challenge, Duchess and Mary Sachs Islands. Interestingly, eastward movement of sediment which caused migration of the eastward island ends at an average rate of 93 feet/year, was noted on North Star and Alaska Island. The growth observed on these eastern island ends over the past 30 years is due to infrequent westerly storm events and to sediment transport reversals induced by local wave refraction effects.

5.4 Sediment Characteristics

During the field investigation, sediment samples were collected at numerous transect sites. During the July field trip, 40 sediment samples were taken, while 67 samples (one at each transect location) were collected during the September field trip.

Initially, it was believed that a size distribution analysis should be performed to quantify the sediment characteristics at each transect location. Close examination in the field, however, showed a high degree of variability of beach sediments along each transect. Thus, the choice of a "typical" sediment sample, intended to represent the sediments at a particular location, was not possible. For this reason, laboratory analysis to determine the precise sediment size distribution has been judged to be a meaningless exercise.

To document the sediment samples, photographs were taken and a visual description was provided in written form. The descriptions are included in the Appendix to this report. The photos of each sample (in 35 mm slide form) and the sediment samples themselves have been forwarded to Exxon Company U.S.A., Production Department, Western Division, Los Angeles.

5.5 Predicted Coastal Changes

Based on the results of this study, general comments can be made concerning the future coastal changes that are expected during the next 50 years within the project study area. A summary of the anticipated changes is presented below for each of the major coastal environments in the Pt. Thomson region.

Mainland Shore: With the exception of the receding coastal bluffs, the mainland shore is expected to retain its relative long-term stability. While shoreline fluctuations have been noted in this area during the recent summer survey period, long-term comparisons show that the general trend is for mild coastal changes to occur.

Flaxman Island: The high rate of bluff recession (averaging 12 feet/year) along the northern shore of Flaxman Island is expected to continue. The on-going erosion along these bluffs has been noted by various observers dating back to the early 1800's. Based on bluff recession comparisons, it appears that the erosion measured this past summer is consistent with that determined for the 1950-1982 period. Assuming that the present bluff recession rate continues, the erosion of the main body of Flaxman Island will be complete within 100 to 200 years.

Barrier Islands: The barrier islands of the study area will continue to fluctuate in form and location in response to the environmental forces of this region. It is difficult to predict specific changes as these fragile sedimentary structures can undergo significant modification in response to very brief storm events. In general, one can expect continued westward migration of the islands at an average annual rate of 70-80 feet/year. Also, southward recession of the island's northern shore at a rate of from 3 -10 feet/year is expected to continue.

The inlets which exist along the barrier islands are highly dynamic. Small inlets can form during a major storm event and can proceed to widen in response to current flow and wave attack, or these inlets can be filled by persistent sediment transport processes. As a result, the ends of the islands adjacent to these inlet are also highly dynamic.

The eventual loss of Flaxman Island as the primary sediment source will lead, in the next few hundred years, to a dramatic reduction in barrier island size.

5.6 Island/Coastal Inundation Potential

The potential for coastal and island flooding to occur exists throughout the study area during westerly storm periods when water levels rise in response to winds and waves. The damage associated with such events is related to the magnitude of both the storm surge and the incoming waves.

Due to low elevations, particular areas of the study region are quite susceptible to flooding during such events. For all the surveyed transects, four categories (the mainland bluffs, the non-bluff mainland, the Flaxman Island bluff, and the barrier islands) have been chosen to represent the characteristic coastal elevations that exist within the study area. The average elevation associated with each category is listed in Table 5.7.

TABLE 5.7

COASTAL ELEVATIONS
PT. THOMSON STUDY AREA

CLASSIFICATION	NUMBER OF SURVEYED MONUMENTS	AVERAGE MAXIMUM TRANSECT ELEVATION	STANDARD DEVIATION
Mainland Bluffs	3	11.75 Ft	4.59 Ft
Non-Bluff Mainland Sites	35	3.85	1.14
Flaxman Bluffs	4	13.77	5.60
Barrier Islands	25	2.79	0.88

It is apparent that the high bluffs on Flaxman Island and at several mainland locations offer the only protection from flooding within the study area. The low-lying mainland coast (mean elevation $< 4'$) and the barrier islands (mean elevation $< 3'$) are subject to flooding during even moderate storm surge episodes.