# PATTERNS OF SEDIMENT DISPERSION ON THE SHORELINE OF AN ERODING BARRIER ISLAND

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ABSTRACT

A study of the sediment budget of the shoreline at Tybee Island illustrated some relationships between sediment transport patterns and patterns of erosion. Sediment eroded from the northeast portion of the Tybee shoreline accumulated at the beach adjacent to ninth street and at the beach along the northwest portion of the island.

Most of the shoreline responded to seasonal changes in energy conditions. During the fall and winter the beaches lost sand. During the spring and summer, the beaches gained sand. Between Third Street and Fourteenth Street, the sediment losses during the fall and winter were generally completely compensated for during the spring and summer recovery period. North of Third Street and South of Fourteenth Street, the sediment recovered during the spring and summer was insufficient to balance the losses of the previous fall and winter.

## INTRODUCTION

Tybee Island is a barrier island located immediately south of the Savannah River entrance. The barrier is approximately $3\frac{1}{2}$ miles long and is generally believed to be Holocene in age (Hoyt and Hails, 1967). Structually the island is composed of beach-dune ridges that have developed across accreting shorelines. Aerial photographs illustrate the trends of these beach ridges although portions of some beach ridges have been altered or destroyed by construction and land development. The ridges vary in elevation from 10 to 18 feet above mean low water.

The development of beach-dune ridges illustrated shoreline advance during the Holocene history of Tybee Island; however, the shoreline history during most of the 20th century has illustrated erosion. In considering the sediment budget of a barrier island, erosion in one place generally implies a transfer of sand away from that area and sediment accumulation in another area. Sediment transfers could take place in several different directions, onshore (into estuaries), offshore, and longshore to the north or south. Each of these processes have occurred in portions of Tybee Island; however, the continuous erosion problem at Tybee Island appears to be related to offshore transfers that produce the lowering of the beach and shoreface profiles. However, sediment is depleted from the beach at a rate equal to the lowering of the adjacent shoreface. The lowering of the beach and shoreface profiles is very apparent adjacent to seawalls, particularly near the north end of the island. Whereas, erosion appears to be relatively continuous at Tybee Island, periods of "peak" erosion are associated with

northeast storms. Periods of beach build-up (accretion) are during low energy summer conditions. However, over the duration of a year there is generally a net loss of sediment from the beach.

Several methods were used to evaluate the patterns of erosion and accretion along the shorelines of Tybee Island. The occurrence and recent development of new beach-dune ridges on the northwest and south shorelines of Tybee Island illustrates where at least some of the eroded sediment has been transported and deposited. Sequential development of beach-dune ridges illustrate the pattern of modern and late Holocene development (Fig. 1). The sequential development of beach ridges (Fig. 1, SQ) documents the accreting and constructional phases of barrier development. Truncations (Fig. 1, T) on the northern most end of Tybee Island illustrate the initial period of constructional modification to barrier development. This apparently took place during the Late Holocene. The truncations of northeast trending beach-dune ridges were followed by the development of beach-dune ridges along the southern shoreline of the island, and on the northwest shoreline of the island (Fig. 1, ridge A through ridge F). During this period, northeast accretion was accomplished adjacent to an extensive sand shoal, as sand from this shoal periodically renourished the northern end of the island following periods of erosion. This process of sand nourishing from offshore shoals is apparently still active today on several of the other barriers along the Georgia coast (Oertel, 1973). At present, the sand shoal that was adjacent to the north end of the island has been reduced to a fraction of its former size and it no longer serves as a major reservoir of sand for this portion of the island. Severe erosion on the northeast portion of the island
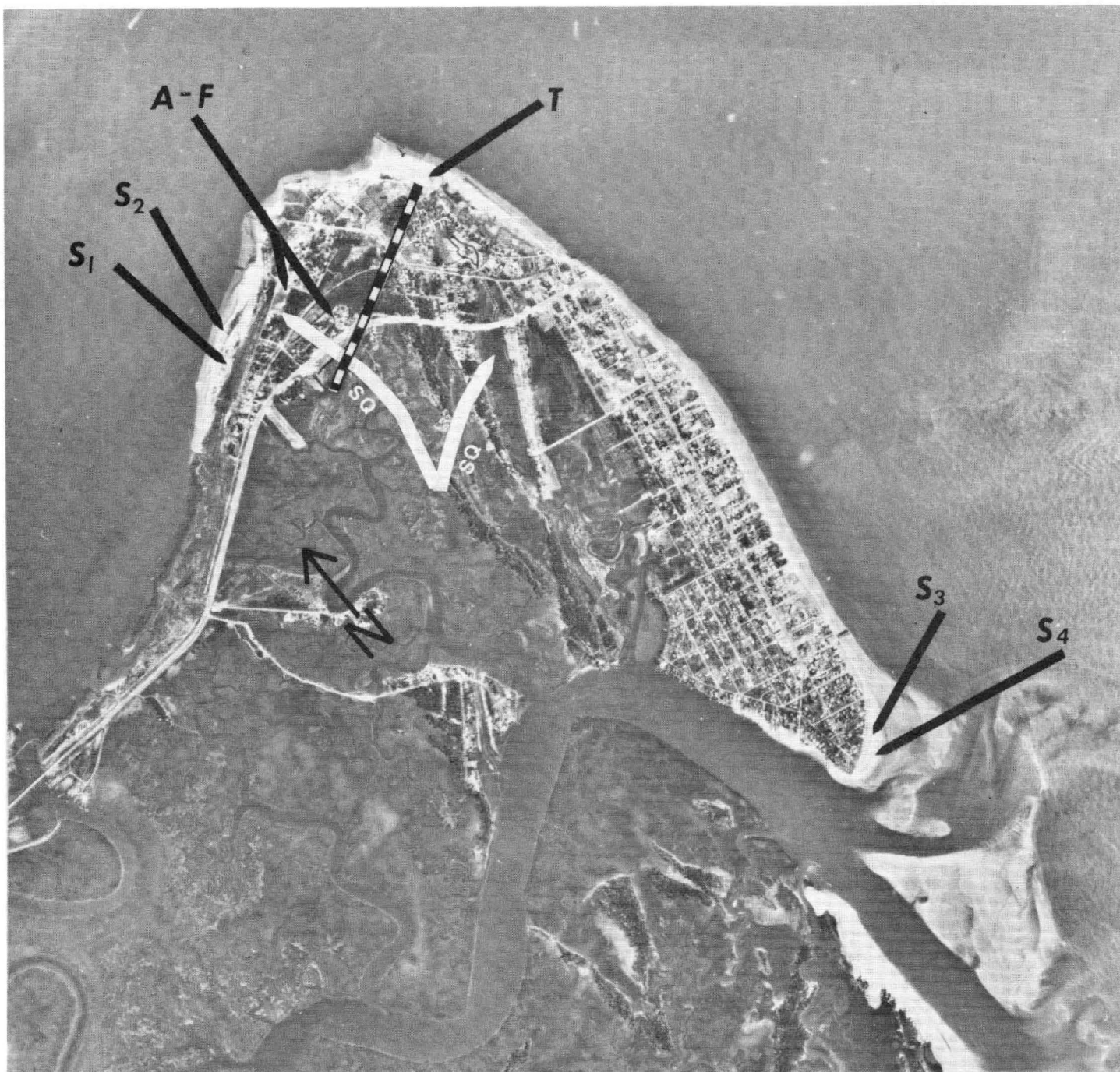
Figure 1.  Aerial photograph of Tybee Island.  The (T) illustrates the approximate position of the beach ridge truncation during the Holocene.  The white arrows (SQ) illustrate the directions of sequential beach-ridge development.  Beach ridges A-F represent the late Holocene development of Tybee Island in a west and northwest direction.  Ridges S1, S2, S3 and S4 are relatively recent dune ridges that illustrate modern accretionary trends of the island.

has caused a great deal of concern, and protective measures in the form of jetties and seawalls have been installed along approximately all of the ocean shoreline that is exposed to waves and strong currents. The northwestern and southern portions of the island continued to accrete as they did previously; however, retreat of other portions of shoreline was stopped by the installment of rock and concrete sidewalk. Presently, several portions of the shoreline north of approximately Third Street have eroded to the base of the seawall where waves and currents are continually dissipating energy.

## CHARACTER OF THE BEACH FACE

The beach along the seaward side of Tybee Island is defined as the sand-surface area between the low water line and a man-made seawall that parallels the shoreline adjacent to the Atlantic Ocean. The beach is broadest at the middle and southern portions of Tybee Island, but becomes very narrow north of Third Street. In some areas on the northern portion of the island the low water line is present at the base of the seawall and the beach is non-existent. Bimonthly measurements and observations were made on the beach between First Street and Sixteenth Street (Appendix A).

In general, the average slope of the beach was very low (1-2$^{\circ}$); however, the slope did vary with respect to the width of the beach (Table 1). North of Sixth Street the beach was generally one degree or less and the beach width varied from 10 to 55 meters. At Sixth Street, the beach slope was approximately one degree and the average beach width was 55-80 meters. Between Ninth Street and Sixth Street, the

## Table 1.

### Average Beach Slope and Number of Beach Ridges

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Oct 4, 1972 | 1:56 | 0 | 1:32 | 0 | 1:25 | 1 | 1:30 | 3 |
| Oct 20, 1972 | 1:46 | 0 | 1:17 | 0 | 1:22 | 0 | 1:23 | 2 |
| Nov 1, 1972 | 1:48 | 0 | 1:40 | 0 | 1:32 | 0 | 1:41 | 1 |
| Nov 17, 1972 | 1:54 | 0 | 1:32 | 0 | 1:28 | 1 | 1:37 | 1 |
| Nov 30, 1973 | 1:50 | 0 | 1:41 | 0 | 1:46 | 0 | 1:40 | 1 |
| Dec 15, 1972 | 1:64 | 0 | 1:34 | 0 | 1:39 | 0 | 1:35 | 2 |
| Jan 5, 1973 | 1:64 | 0 | 1:32 | 0 | 1:30 | 1 | 1:29 | 1 |
| Jan 19, 1973 | 1:46 | 0 | 1:35 | 0 | 1:33 | 0 | 1:27 | 1 |
| Feb 3, 1973 | 1:76 | 0 | 1:26 | 1 | 1:26 | 1 | 1:25 | 1 |
| Feb 16, 1973 | 1:52 | 0 | 1:41 | 0 | 1:35 | 0 | 1:45 | 1 |
| Mar 2, 1973 | 1:64 | 0 | 1:55 | 0 | 1:29 | 1 | 1:37 | 1 |
| Mar 16, 1973 | 1:60 | 0 | 1:38 | 1 | 1:40 | 2 | 1:36 | 1 |
| Mar 30, 1973 | 1:68 | 0 | 1:35 | 0 | 1:30 | 1 | 1:25 | 1 |
| Apr 16, 1973 | 1:66 | 2 | 1:34 | 2 | 1:35 | 2 | 1:25 | 1 |
| Apr 27, 1973 | 1:62 | 0 | 1:35 | 2 | 1:32 | 1 | 1:31 | 0 |
| May 12, 1973 | 1:66 | 0 | 1:32 | 1 | 1:29 | 1 | 1:32 | 2 |
| May 28, 1973 | 1:56 | 1 | 1:28 | 1 | 1:34 | 1 | 1:31 | 1 |
| June 8, 1973 | 1:56 | 0 | 1:24 | 1 | 1:28 | 1 | 1:24 | 1 |
| June 25, 1973 | 1:56 | 1 | 1:23 | 1 | 1:31 | 1 | 1:28 | 1 |
| July 6, 1973 | 1:53 | 1 | 1:29 | 1 | 1:26 | 1 | 1:42 | 1 |
| July 20, 1973 | 1:36 | 1 | 1:36 | 0 | 1:29 | 0 | 1:34 | 0 |
| Aug 3, 1973 | 1:28 | 1 | 1:29 | 1 | 1:30 | 1 | 1:36 | 1 |
| Aug 20, 1973 | 1:45 | 1 | 1:25 | 2 | 1:31 | 2 | 1:37 | 1 |
| Sept 6, 1973 | 1:41 | 0 | 1:23 | 1 | 1:30 | 2 | 1:27 | 1 |
| Sept 25, 1973 | 1:38 | 0 | 1:26 | 0 | 1:29 | 2 | 1:34 | 1 |
| Oct 8, 1973 | 1:45 | 0 | 1:32 | 0 | 1:37 | 0 | 1:44 | 0 |
| Average Slope | 1:54.2 | | 1:31.3 | | 1:31.4 | | 1:32.5 | |

Number of Beaches with
Ridges/total number of ridges  7/8       11/14       11/23       22/28

Average Slope in
Degrees   $1^{\circ}\ 9'$   $1^{\circ}\ 50'$   $1^{\circ}\ 50'$   $1^{\circ}\ 45'$

average beach slope increased to approximately two degrees and the average width
of the beach was approximately 80-100 meters. Wider portions of beach had a more
undulating topography. By counting the number of swash bars that transected a pro-
file, an estimate was made of how flat the various portions of the beach were for the
period between October 4, 1972 and October 8, 1973. In general, a larger number
of ridges were present on the southern and wider portion of the beach than were on
the northern portion of the shoreline (Table 1, Appendix A). On a seasonal basis,
there were exactly twice as many swash bars observed during the spring and summer
than were observed during the fall and winter (Table 1). From these trends it would
appear that increasing numbers of swash bars are generally associated with spring and
summer beaches and relatively wide beaches. Following trends of increasing or de-
creasing numbers of beach ridges may be a barometer to the stability of a beach, that
is whether the future development of the beach follows a pattern of erosion or accretion.
During the study period, the number of beach ridges per season (fall, winter, spring,
summer) at Sixteenth Street decreased continually; whereas, the amount of erosion
increased.

BEACH PROFILES

On October 4, 1972 beach-profile surveying was begun on Tybee Island. Every
two weeks, beach profiles were made from the seawall to the low water line. Profiles
were made at Sixth Street, Ninth Street, Twelfth Street, Sixteenth Street and single
beach elevations were made adjacent to Third Street and Tilton Street. These profiles

were made over the duration of a year, and were an attempt to see how the various portions of the shoreline responded to seasonal changes (Appendix A).

OBSERVATIONS

Cumulative volumes of sand (based on beach profiles) were plotted against time for one complete season (Fig. 2, 3, 4, 5). These plots illustrate the seasonal fluctuations in the sediment budget of various portions of the Tybee shorelines (Sixth, Ninth, Twelfth and Sixteenth Streets). The shoreline in the central portion of Tybee Island between Sixth Street and Twelfth Street (Fig. 3, 4, 5) had remarkably similar seasonal trends. Initially during the fall and winter, erosion lowered the beach face in response to a "drain" in the sediment budget. However, during the summer and spring the beach face began to build up as the sediment budget responded to sediment input. Although relatively large deficits in the sediment budget produced severe erosion during the fall and winter, build ups during the spring and summer produced complete recovery of all of the lost sediment. However, after a one year sampling period a small deficit (-5, 842 cu m) was calculated for this area (Fig. 6).

North of Sixth Street, erosion also lowered the beachface during the fall and winter; however, recovering during the spring and summer was slow and a relatively large seasonal deficit was illustrated by the lack of any high-tide beach and only a very small low-tide beach east of the seawall.

Between Twelfth Street and Sixteenth Street the beach illustrated a large net deficit (-20,484 cu m) in the sediment budget. This area began eroding during the fall
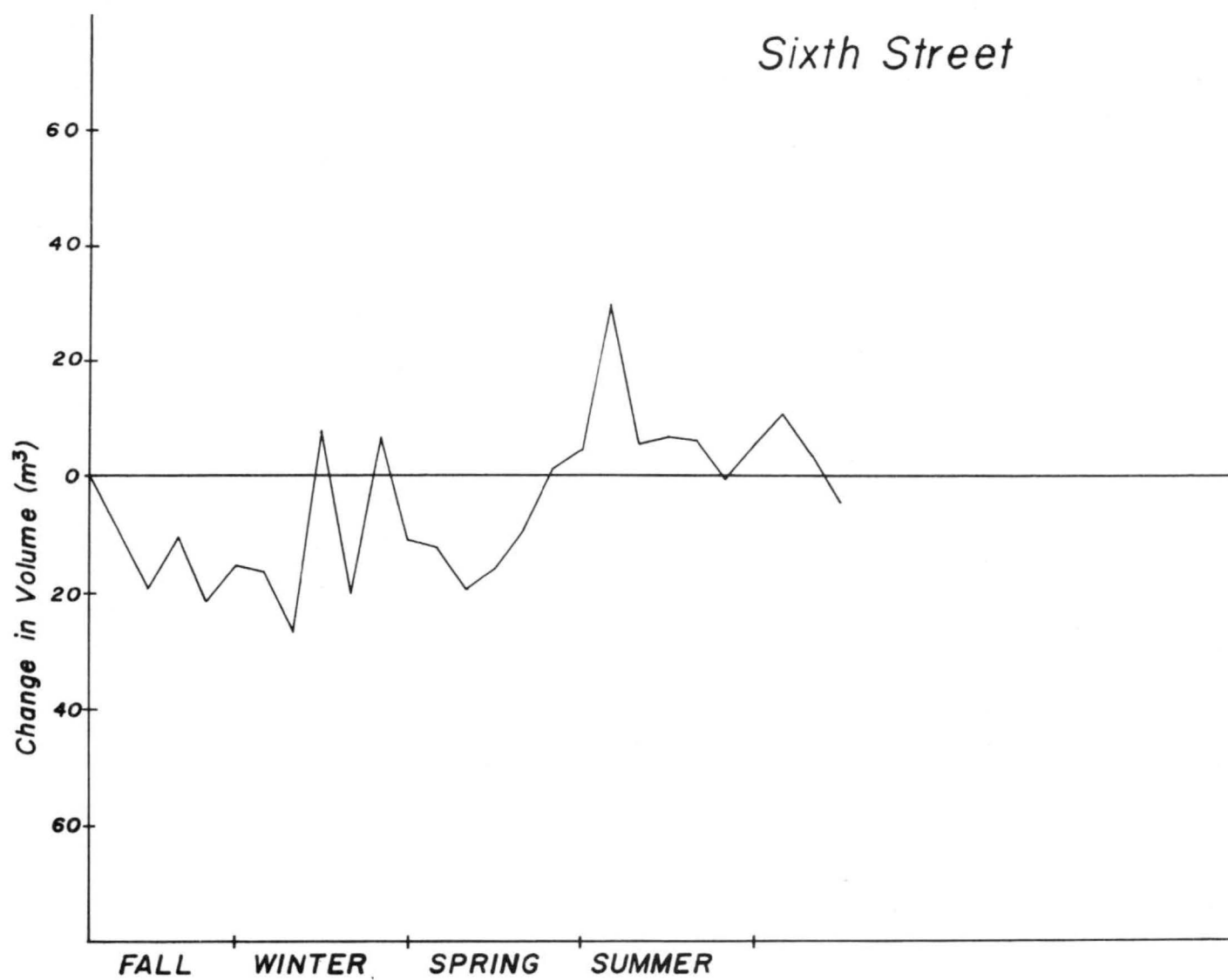
Figure 2.  Graph illustrating cumulative volumes of sand at a one-meter wide
transect across the Sixth Street beach.  Spring and summer accretion
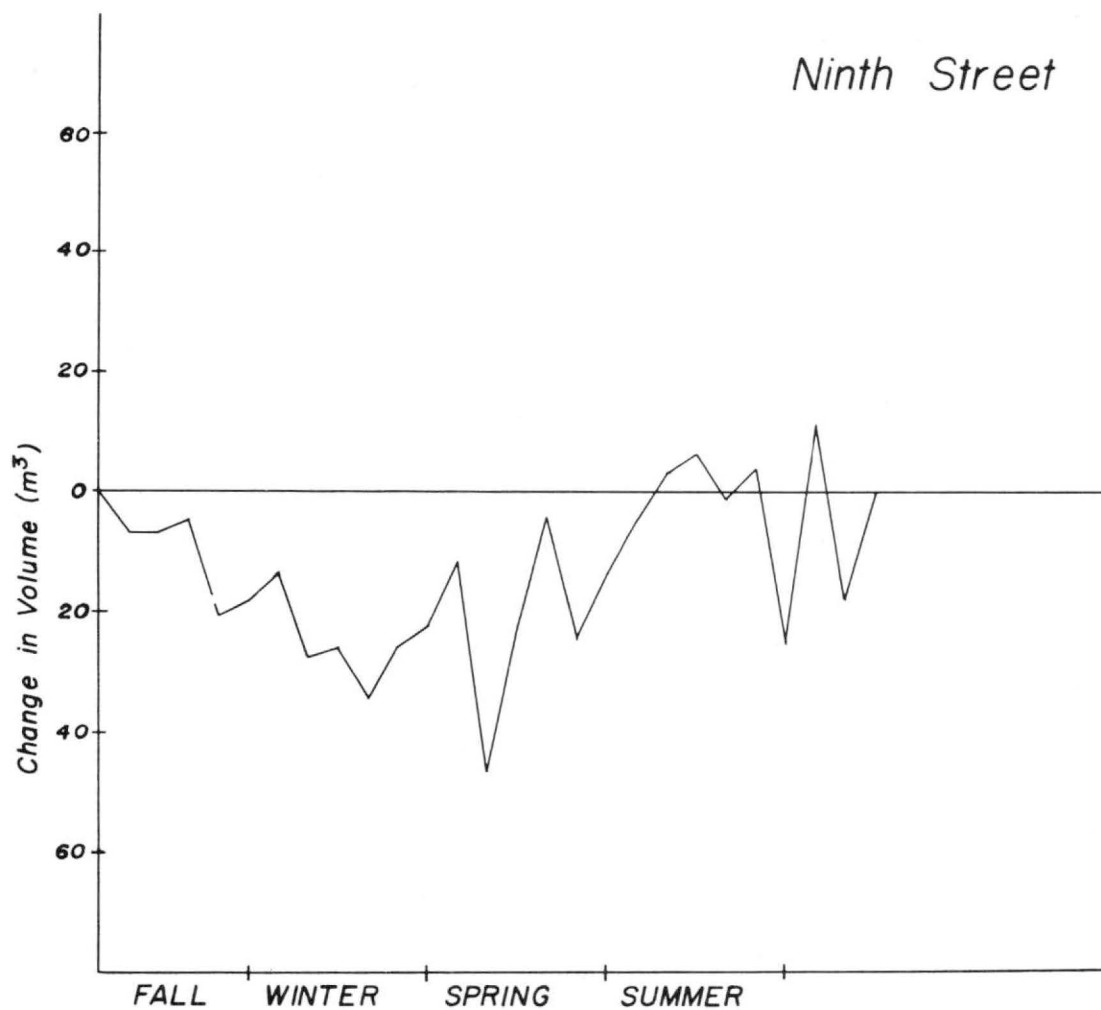more than compensates for fall and winter erosion.

Figure 3. Graph illustrating cumulative volumes of sand at a one-meter wide transect across the Ninth Street beach. Spring and summer accretion just compensates for fall and winter losses.
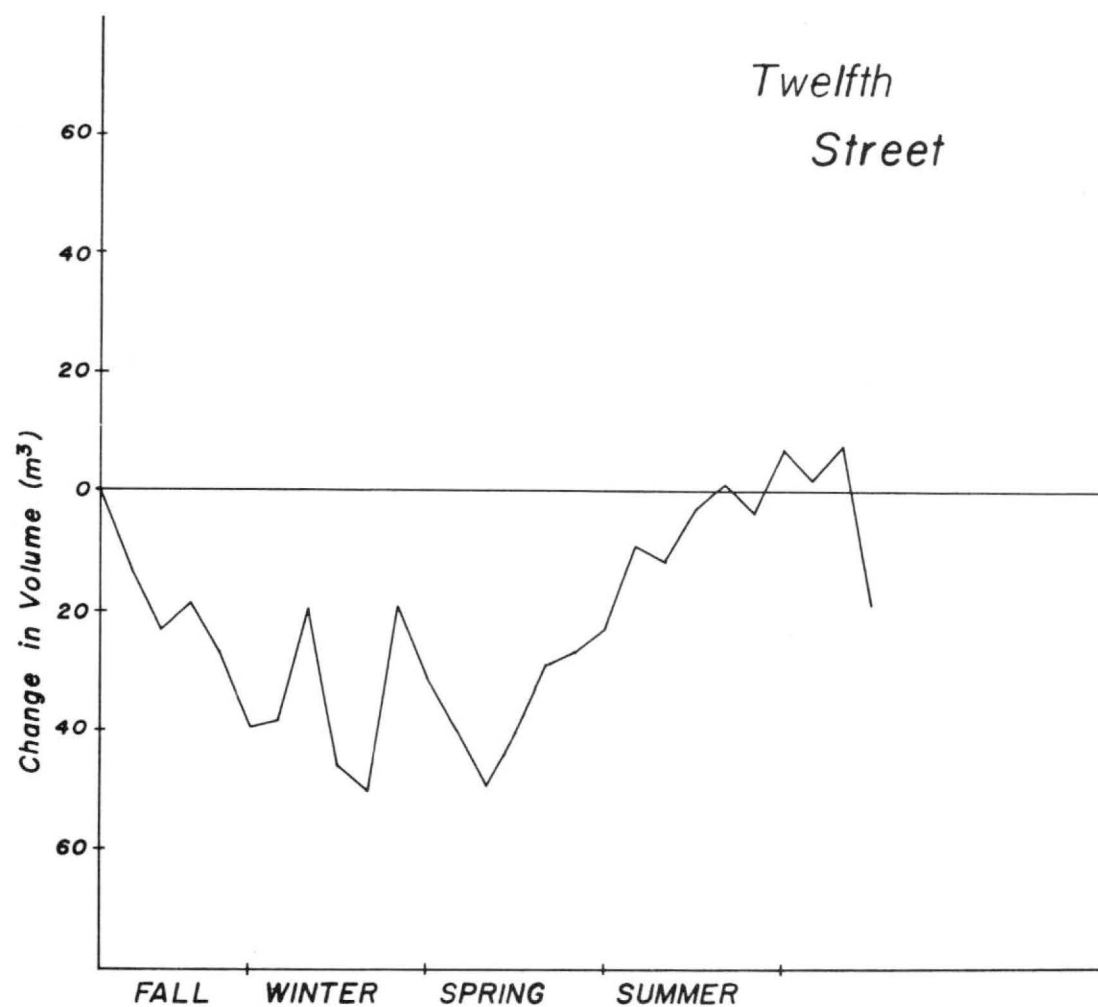
Figure 4.  Graph illustrating cumulative volumes of sand at a one-meter wide transect across the Twelfth Street beach.  Spring and summer accretion just compensates for fall and winter losses.
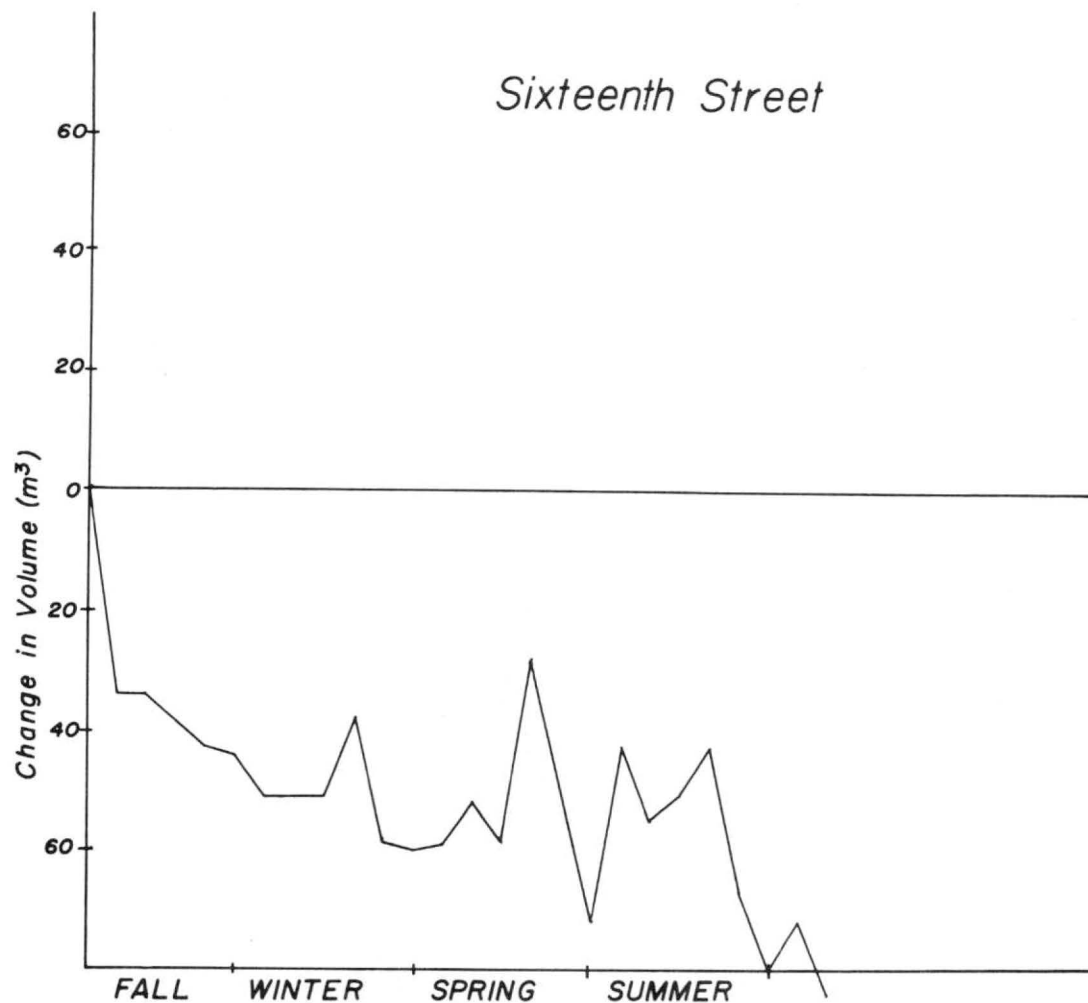
Figure 5.  Graph illustrating cumulative volumes of sand at a one–meter wide transect across the Sixteenth Street beach.  A relatively continuous erosion trend was present during fall and winter.  An accretionary trend in the early spring was balanced by an erosional trend in late spring.  An accretionary trend in early summer was also erased by an erosional trend in late summer.  The result is an erosional trend for the entire year.
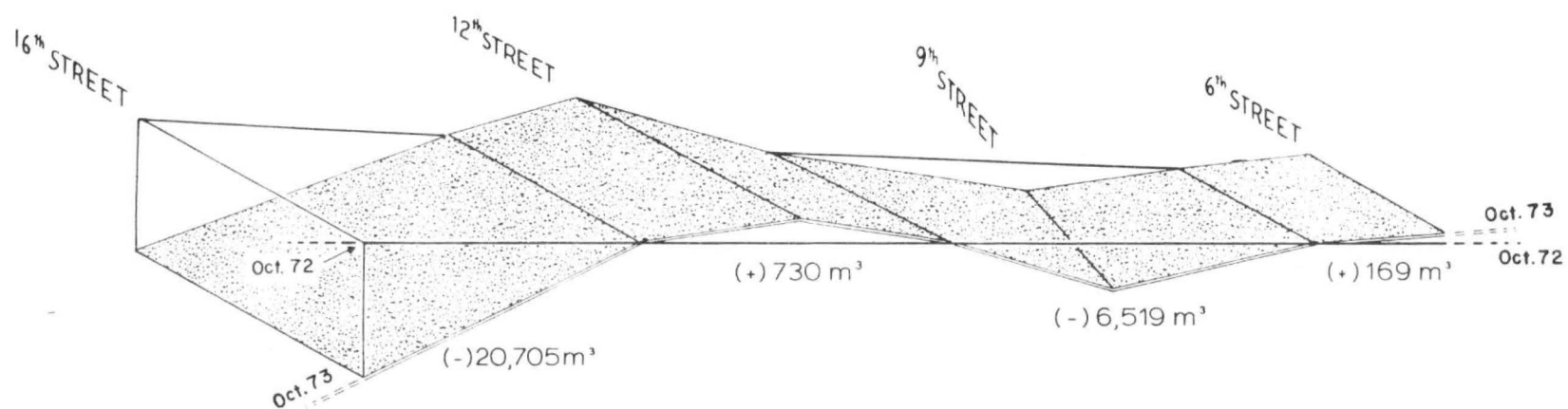
Figure 6. Box diagram illustrating the yearly pattern of erosion and accretion for portions of Savannah Beach (not to scale).

and winter, but had only a small recovery period during the spring and summer.

Accretion during the spring and summer was insufficient to balance the severe periods of erosion. During the season between October 4, 1972 and October 8, 1973 the central portion of Tybee Island suffered extreme erosion during fall and winter, but recovered almost completely during the spring and summer periods of accretion (Fig. 6). The beaches north of Third Street and south of Fourteenth Street also suffered extreme erosion during the fall and winter; however, recovery during the spring and summer was somewhat smaller. At the northern end of the island, this trend may be an indication of the effect of the sediment loss into the Savannah River channel

## SAND DISPERSION

Although continuous beach-profile surveys are useful in determining the net gain or loss of sediment from portions of beach, supplementary data is often necessary to gain an understanding of the mechanics and patterns of sediment dispersion that is associated with erosion or accretion. Wave currents and tidal currents are considered to be the prevailing and predominant agents of sediment transport along the Georgia shoreline (Oertel, 1972, 1973). Flooding tidal currents entrain beach sediment toward the Savannah River entrance; whereas, ebbing currents entrain beach sediment offshore at the north end of the island and have little effect on the center and southern shorelines of Tybee Island. Onshore waves generally refract around a "break point" in the shore-line at approximately Sixth Street. As waves break along the shoreline they produce longshore currents that flow to the north or to the south, respectively, from this point.

The point of flow reversal is generally south of Sixth Street because of a topographic high in offshore topography.

The patterns of sediment transport produced by wave currents and tidal currents were evaluated by utilizing several tagged-grain studies. Sand taken from several potential test sites was dryed and coated with a commercial, fluorescent paint. Two different hues were used in differentiating the grains used at each test site. Color-coded grains were returned to their respective test-run sites and released on the sea bed. The duration of interaction with physical processes was carefully determined so that grains were exposed to equal durations of ebbing and flooding tidal currents. Two test sites used are illustrated as A and B in Figure 7.

On February 26, 1973 two tracer experiments using fluorescent sand were conducted on Tybee Island. Adjacent to Tilton Street, there is no high-tide beach, and only a very narrow low-tide beach. Sand coated with a yellow-fluorescent acrylic and weighing approximately 150 pounds was released on the beach face at point R (Fig. 8). Northward flowing flood currents initially interacted with the tagged grains for four hours, after high water, tidal currents reversed and ebbed southward for $3\frac{1}{2}$ hours. Sampling was conducted after grains interacted with the sedimentary environment for a total of seven and one half hours. Although winds were out of the northeast, the refraction of swells at the beach produced a northerly longshore current within the breaker zone. The sample grid illustrated on Figure 8 shows the pattern of fluorescent sand dispersion for the seven and one half hour period described. Although grain recovery was modest, transport  patterns were consistantly in a northerly direction along the shoreline. Fluorescent grains apparently penetrated through the "breaks" in

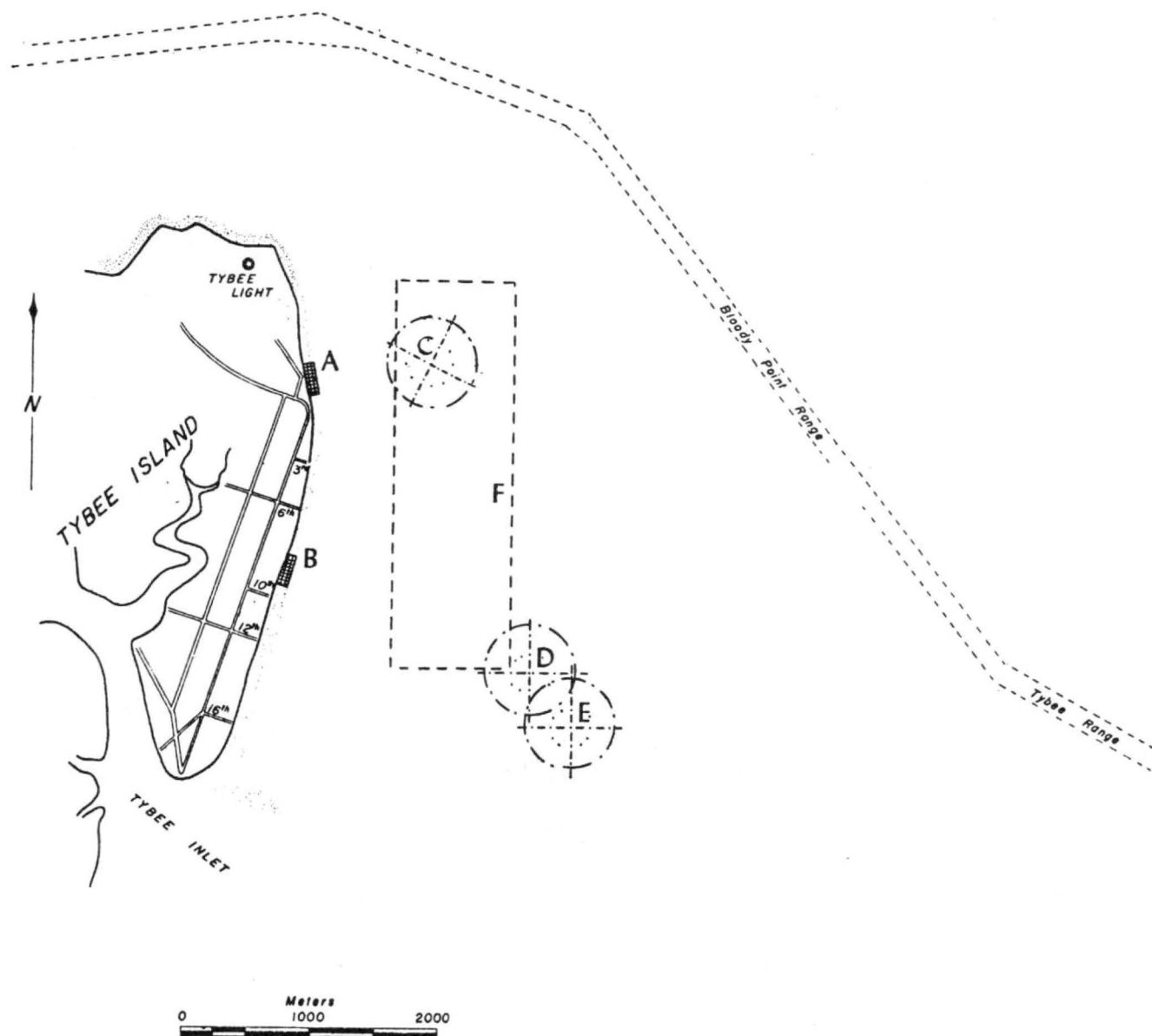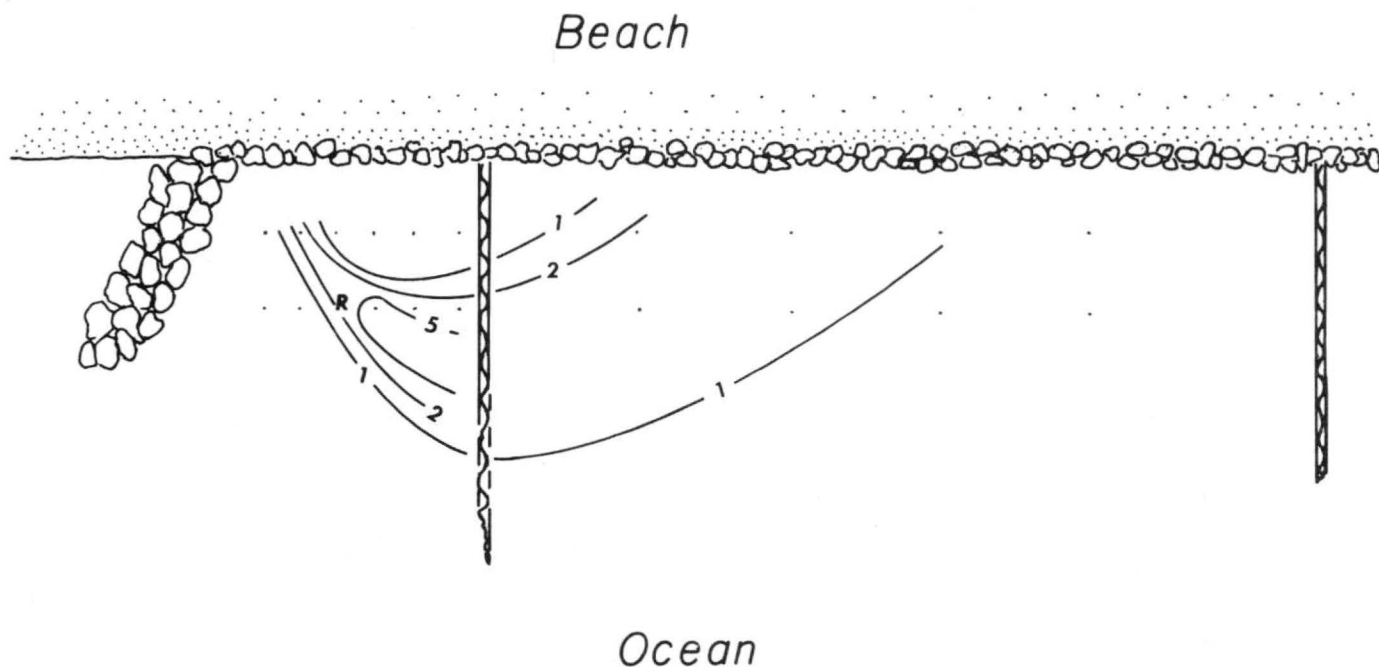Figure 7.    Index map of sample grids for fluorescent-sand tracing experiments.

Figure 8. Map of fluorescent-grain dispersion of sample grid A (February 26, 1973). Approximately 150 lbs of sand coated with a yellow-fluorescent acrylic were released on the beach face at point R. Sampling was made after an initial flood duration of 4 hours followed by an ebb duration of $3\frac{1}{2}$ hours. Contours are in grains per 100 sq cm.

the old steel groin. The very modest recovery may be an indication that sand was moving offshore, and out of the sample grid.

Another sand-tracer experiment was simultaneously conducted between Seventh and Eighth Streets (fig. 9). Sand coated with an orange-fluorescent acrylic and weighing approximately 150 pounds was released on the sea bed of the foreshore. Grains were allowed to interact with agents of transportation for approximately $6\frac{1}{2}$ hours. Grains interacted with ebbing currents for two and one half hours and with flooding currents for four hours. The highest concentration of fluorescent grains was recovered just south of the release point, and adjacent to a wood jetty (fig. 9). This high concentration is believed to be related to the onshore transport of sediment associated with "swash currents". Sediment dispersion was both northward and southward along the shoreline; however, the predominant trend of transport was in a northward direction. Ebbing and flooding currents are apparently both responsible for transporting some sediment in opposite directions during respective periods of the tide. During the ebbing tide, tidal currents enhance the flow of sediment toward the south, and during the flooding tide, tidal currents enhance the transport of sediment in a northerly direction. In that recovery extended a greater distance north of the release point it may be assumed that on this day there was a net transport of sediment to the north. The relatively high concentrations found on the upper portions of the beach also illustrate the effectiveness of swash currents in building the beach during this period. Our profiling records show that the beach adjacent to Ninth Street was indeed building in late February and early March.
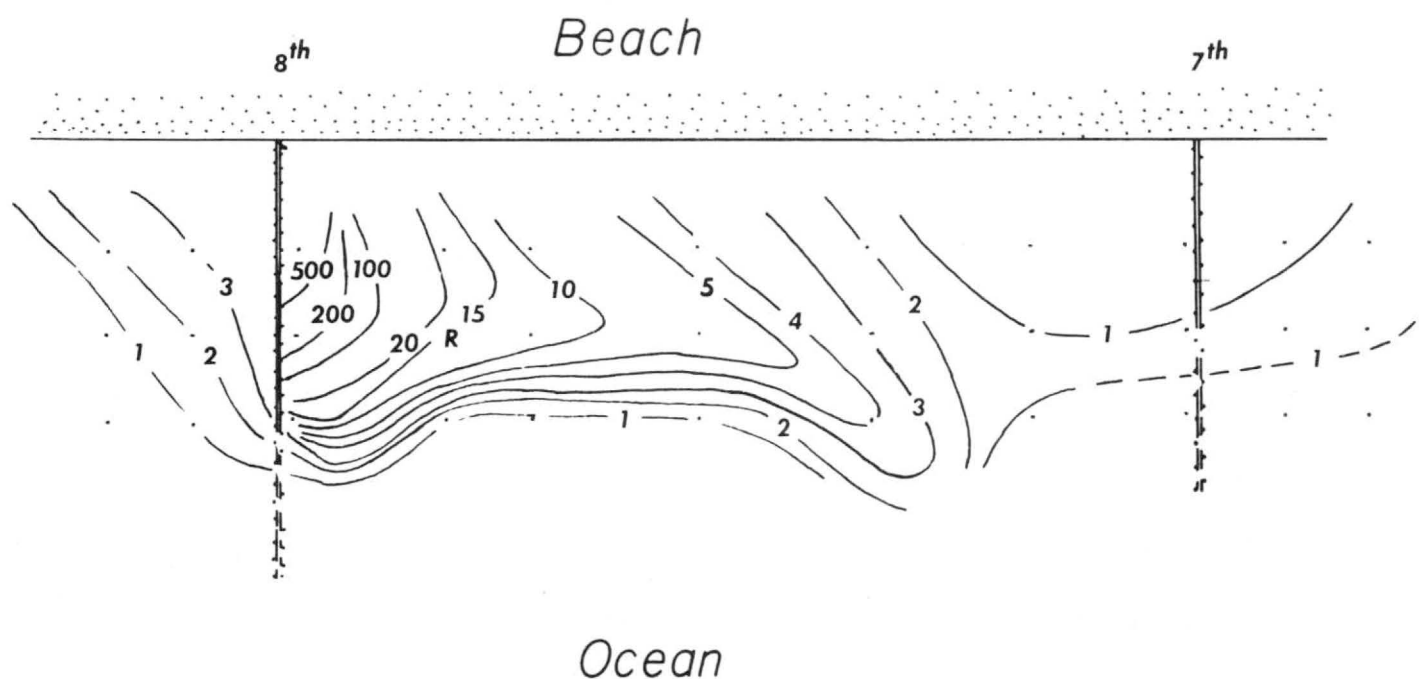
Figure 9. Map of fluorescent-grain dispersion at sample-grid B (February 26, 1973). Approximately 150 lbs of sand coated with an orange-fluorescent acrylic were released on the beach face at point R. Sampling was made after an initial flood duration of $2\frac{1}{2}$ hours followed by an ebb duration of 4 hours. Contours are in grains per 100 sq cm.

On May 22, 1973 tracer experiments were repeated at the two experimental sites described above. The interaction period again "straddled" high water, having four hours of exposure to ebbing currents and four hours of exposure to flooding tidal currents. The winds were variable with low speeds and the sea condition was essentially smooth.

The experiment conducted adjacent to Tilton Street produced results that were very similar to the results determined for February 26, 1973; however, the amount of recovery was much greater (fig. 10). The maximum recovery was landward and north-ward of the release point. Fluorescent sand was again able to penetrate the old, dilapi-dated, steel groin and isopleths illustrated strong tendencies for sediment transport to the north. The relatively high recovery and onshore transport of sand in figure 9 may be interpreted as an accretional trend. This is in contrast to the possible offshore transport trend that was depleting the sediment budget on February 26, 1973.

The May 22, 1973 tracer experiment conducted between Seventh and Eighth Streets produced results similar to the earlier experiment conducted at this site (fig. 11). The dispersion patterns appeared to illustrate a general transport trend to the north; however, the dispersion patterns were locally very complicated. The greatest re-covery of fluorescent grains was slightly northward and onshore of the release point (R). This onshore trend was interpreted as an indication of beach building, and was later substantiated by the volumes calculated from profiles taken in late May. "Rip" currents along the margins of the wooden jetties produced channels that transported sediment offshore and depleted the concentration of tagged sand adjacent to the jetties.

Figure 10. Map of fluorescent-grain dispersion of sample-grid A (May 22, 1973). Approximately 150 lbs of sand coated with a yellow-fluorescent acrylic were released on the beach face at point R. Sampling was made after an initial flood duration of 4 hours followed by an ebb duration of $3\frac{1}{2}$ hours. Contours are in grains per 100 sq cm.
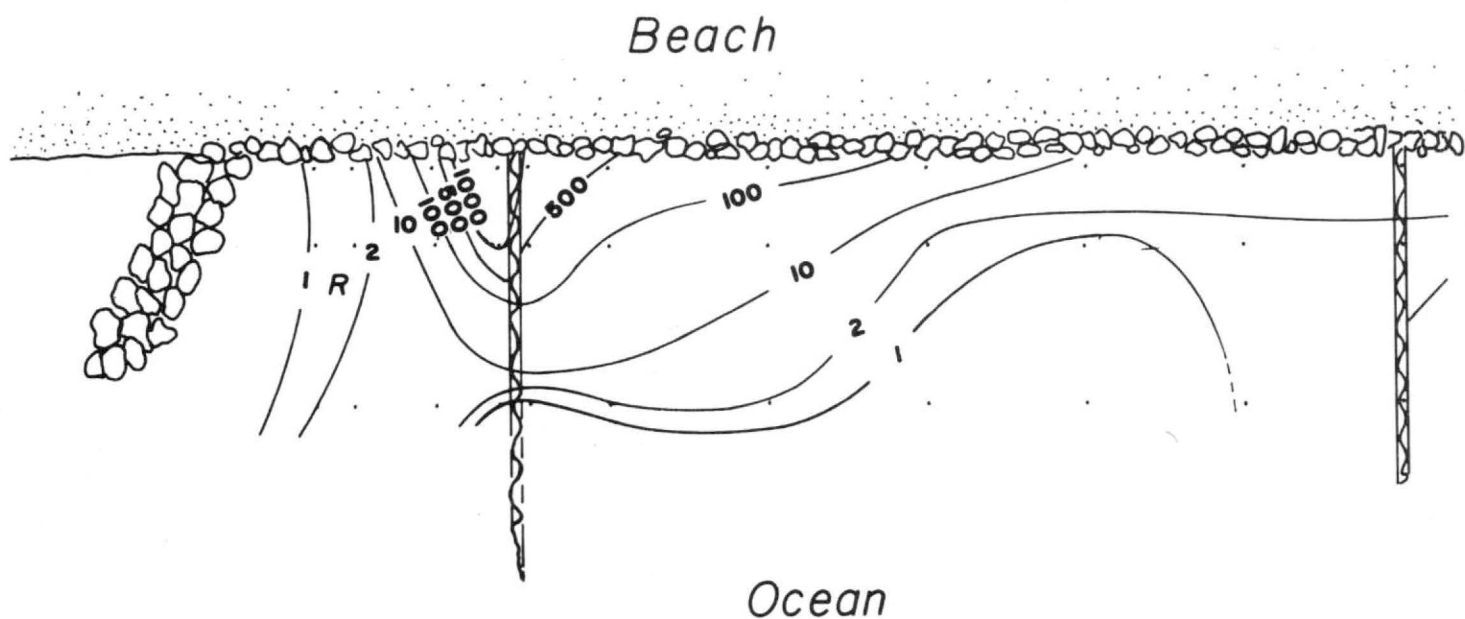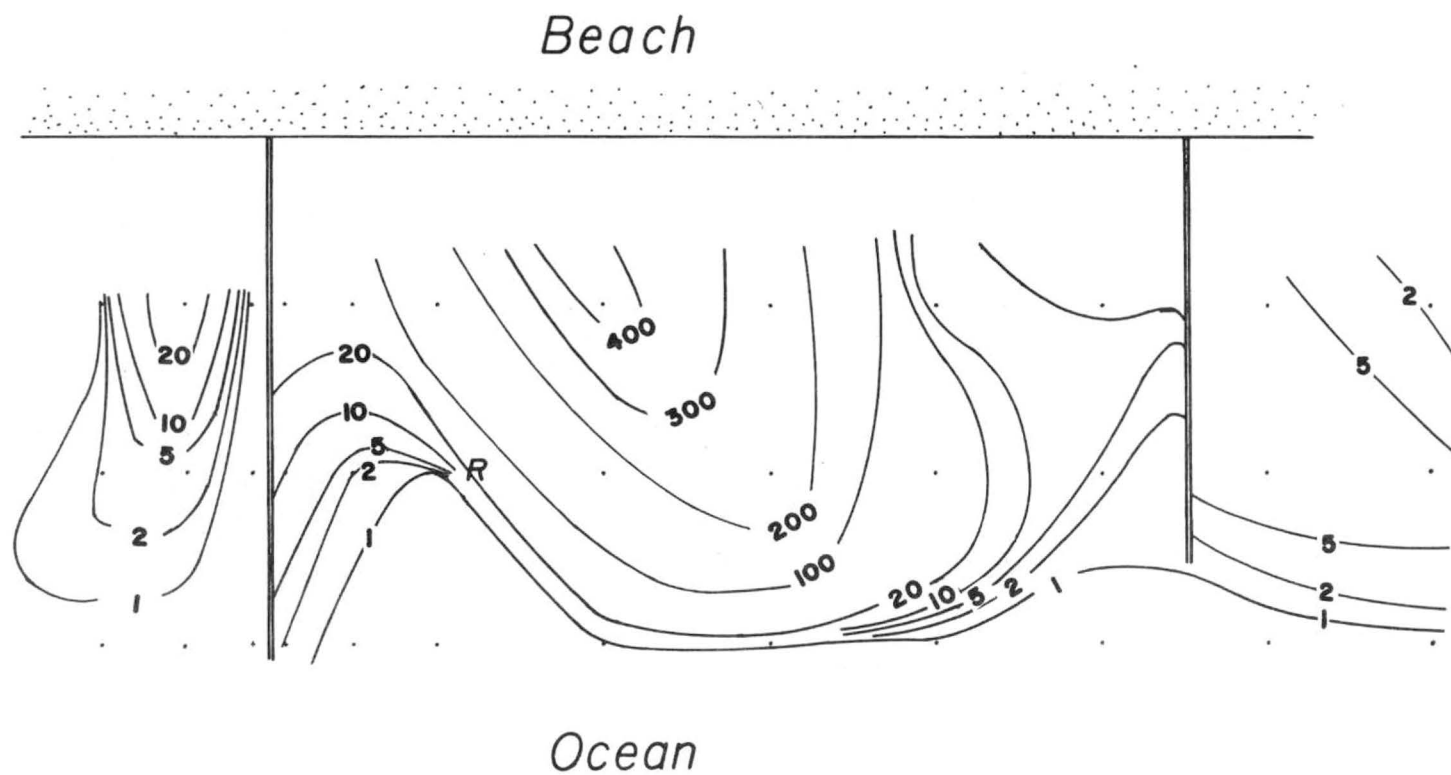
Figure 11.  Map of fluorescent-grain dispersion at sample-grid B (May 22, 1973). Approximately 150 lbs of sand coated with an orange-fluorescent acrylic were released on the beach face at point R.  Sampling was made after an initial flood duration of $2\frac{1}{2}$ hours followed by an ebb duration of 4 hours. Contours are in grains per 100 sq cm.

Tagged sand also was able to move around the ends of the wooden jetties in northerly and southerly directions. On the southside of the Eighth Street jetty, the recovery of tagged sand attenuated significantly 30 meters away from the jetty, and the greatest recovery of tagged sand was in the upper portion of the beach. Swash currents associated with wave refraction are believed to be responsible for the accumulation of sediment in the upper portion of this beach.

In that this experiment was conducted on a relatively calm day during mean tides, it is expected that magnitudes of sediment transport would be very different during spring tides or storms. However, the prevailing influence of the mean tidal currents (flowing to the north) must be considered an important mechanism of sediment transport.

## CONCLUSIONS

Wave-induced currents and tidal currents both play important roles in affecting the sediment budget at Tybee Island. North of Ninth Street, flooding tidal currents appear to be a major mechanism contributing to sediment depletion and to the longshore transport of sediment in a northerly direction.

Wave-induced currents also have a significant affect on the sediment budget of Tybee Island. There is generally a seasonal trend corresponding to different directions of wave approach. During the spring and summer months, wave approach is generally from the southern quadrants. These waves generally produce longshore currents that flow northward and transport sand in a northerly direction. During fall and winter months,

wave approach is generally out of the northern quadrants. During this period, the resultant currents and sediment transport are generally toward the south or west. In response, sand bars are "welded" onto the northwest and southern portions of the island.

During a major portion of the year, wave approach is essentially parallel to the shoreline and longshore sediment transport is bi-polar away from Eighth Street (as described above). Offshore swell is also oblique to the shoreline for a major portion of the year and as waves approach the shoreline, the orientations of the shoreline and the nearshore topography become very significant. The shoreline of Tybee Island is approximately oriented along a north-south bearing; however, north of Sixth Street, the shoreline bends slightly toward the northwest. Also, north of Third Street the water is relatively deep adjacent to the shoreline; whereas, south of Third Street the water stays shallow for a considerable distance offshore. Wave refraction around this shallow area produced a southerly longshore current (south of Sixth Street) and a northerly longshore current (north of Sixth Street). At the north end of the island, the combination of the wave-induced longshore currents and flooding tidal currents transported sand toward the navigation channel of the Savannah River. Strong ebb tidal currents in this channel transported the sand offshore. Wave-induced longshore currents also transported sand around the northern tip of the island where it was deposited on a recurved spit (fig. 1, S1 and S2). Deposition also occurred in spits at the southern end of the island (fig. 1, S3 and S4). This accretionary trend permits the ends of the barrier island to maintain their widths as the shoreline retreats landward.

At the southern end of Tybee Island a large ebb delta is present adjacent to the Tybee River entrance. This ebb delta is a large sand shoal that is a reservoir of sand for the Tybee shoreline. Distributary tidal channels play important functions in transporting sand to portions of the shoreline. North flowing currents and onshore flowing currents generally nourish the adjacent beach with sand during the spring and summer months.

During the 1972-1973 study period, sand from the ebb delta apparently reentered the shoreline adjacent to Ninth and Tenth Streets. A submarine spit from the ebb delta recurved toward a sand shoal extending offshore from Tenth Street. The onshore transport of sediment from this spit produced a good spring and summer recovery period for the adjacent portion of the shoreline.

In terms of a sediment budget, the shoreline of Tybee Island has two apparent sources of sand, viz. the ebb tidal deltas at Tybee Inlet and the Ninth Street offshore shoal. The dunes are generally not a reserve source of sand for the shoreline because of the restrictive nature of the seawall.

There are also several drains in the sediment budget. The north end of the island (north of Third Street) appears to have a sediment drain toward the navigation channel and toward the recurved spits on the northwest side of the island. During the fall and winter, the profile of the shoreface is lowered, as sediment is apparently lost in an offshore direction. During major storms sediment was also transported away from the northern tip of the island and toward the southern and northwestern ends of the island.

During the spring and summer months, a combination of wave-induced currents and residual tidal currents transported sediment toward the navigation channel of the

Savannah River. Strong tidal currents in the navigation channel transport sediment away from the Tybee Island sediment system.

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APPENDIX A

Bimonthly Beach Profiles (1972-1973)

for Sixth, Ninth, Twelfth and Sixteenth Streets

Sixth Street Beach Profiles

Sixth Street Beach Profiles

October 4, 1972

October 20, 1972

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Sixth Street Beach Profiles

November 1, 1972

November 17, 1972

Horizontal Scale –   Small square equals 50 centimeters

Vertical Scale –     Small square equals 5 centimeters

Sixth Street Beach Profiles

0    10    20    30    40    50    60    70    80    90    100    110

November 30, 1972

0    10    20    30    40    50    60    70    80    90    100    110

December 15, 1972

Horizontal Scale –    Small square equals 50 centimeters

Vertical Scale –    Small square equals 5 centimeters

Sixth Street Beach Profiles

January 5, 1973

January 19, 1973

Horizontal Scale –    Small square equals  50 centimeters

Vertical Scale –    Small square equals 5 centimeters

# Sixth Street Beach Profiles

| 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |

February 3, 1973

| 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |

February 16, 1973

Horizontal Scale –    Small square equals 50 centimeters

Vertical Scale –    Small square equals 5 centimeters

| 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 |
|---|----|----|----|----|----|----|----|----|----|-----|-----|

Sixth Street Beach Profiles

March 2, 1973

↓ 40 cm

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Sixth Street Beach Profiles

March 16, 1973

March 30, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale –    Small square equals 5 centimeters

Sixth Street Beach Profiles

April 16, 1973

April 27, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Sixth Street Beach Profiles

May 12, 1973

May 28, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Sixth Street Beach Profiles

June 8, 1973

June 25, 1973

Horizontal Scale - Small square equals 50 centimeters
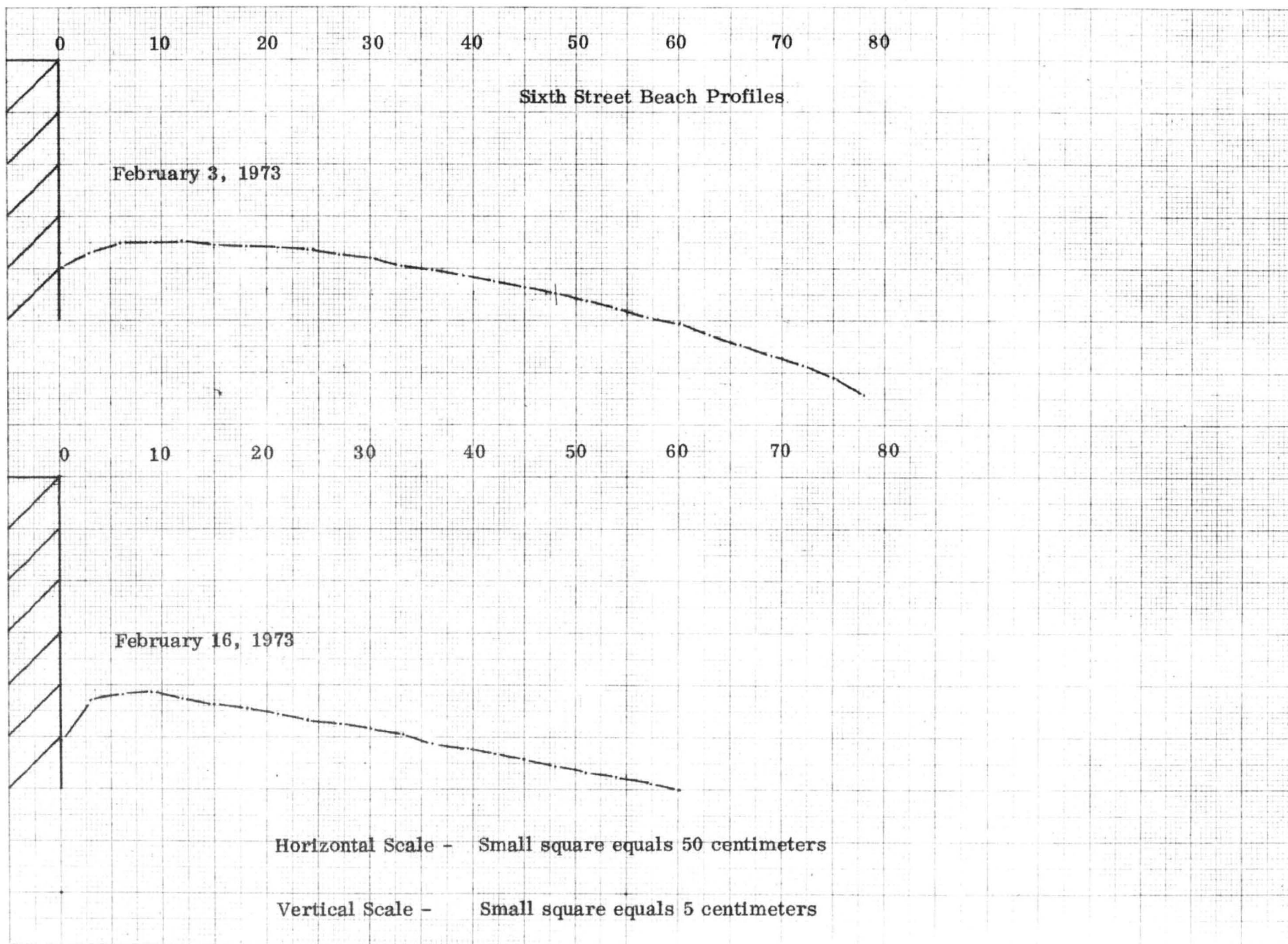
Vertical Scale - Small square equals 5 centimeters

Sixth Street Beach Profiles

July 6, 1973

July 10, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Sixth Street Beach Profile

August 3, 1973
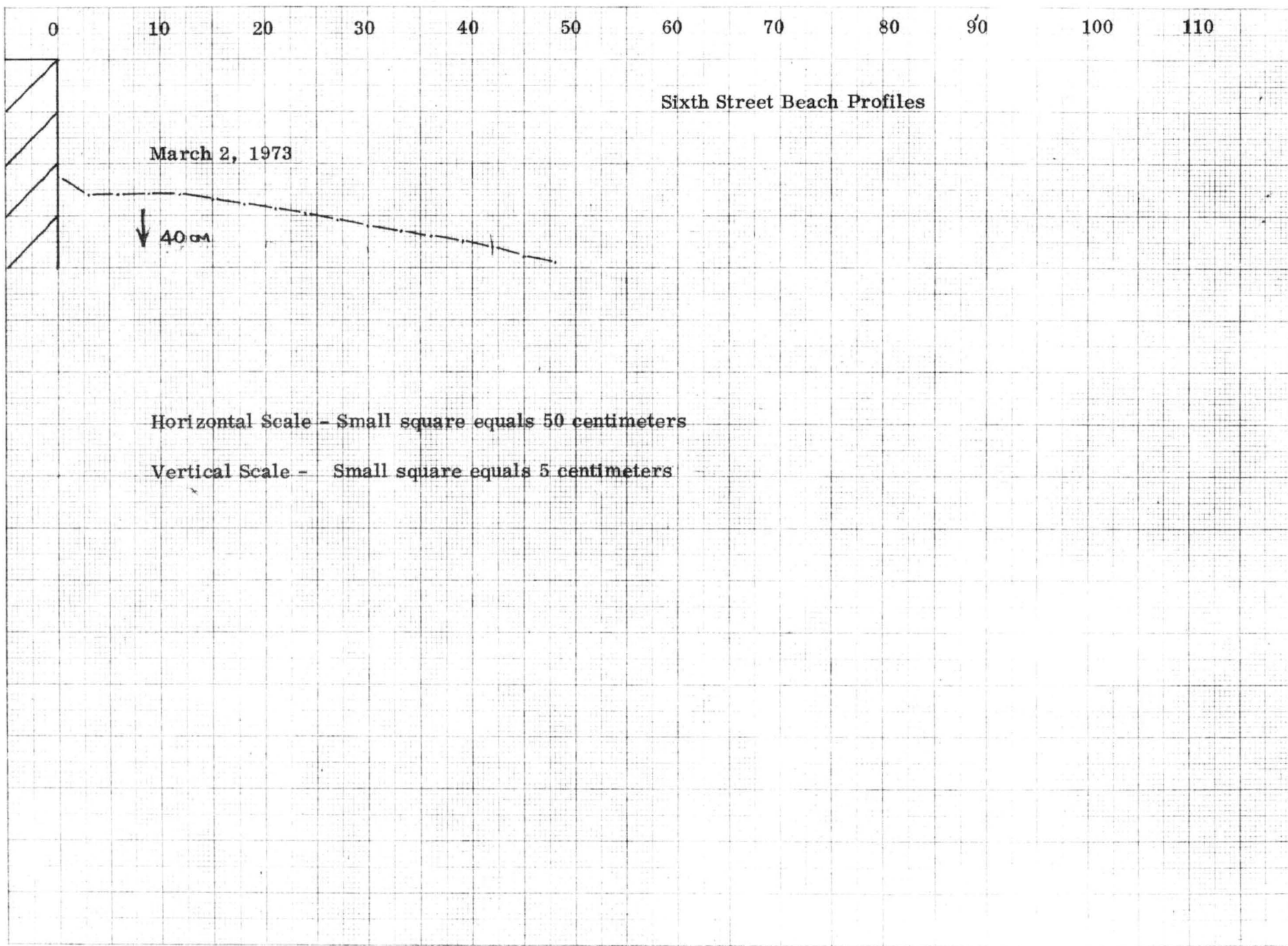
August 20, 1973
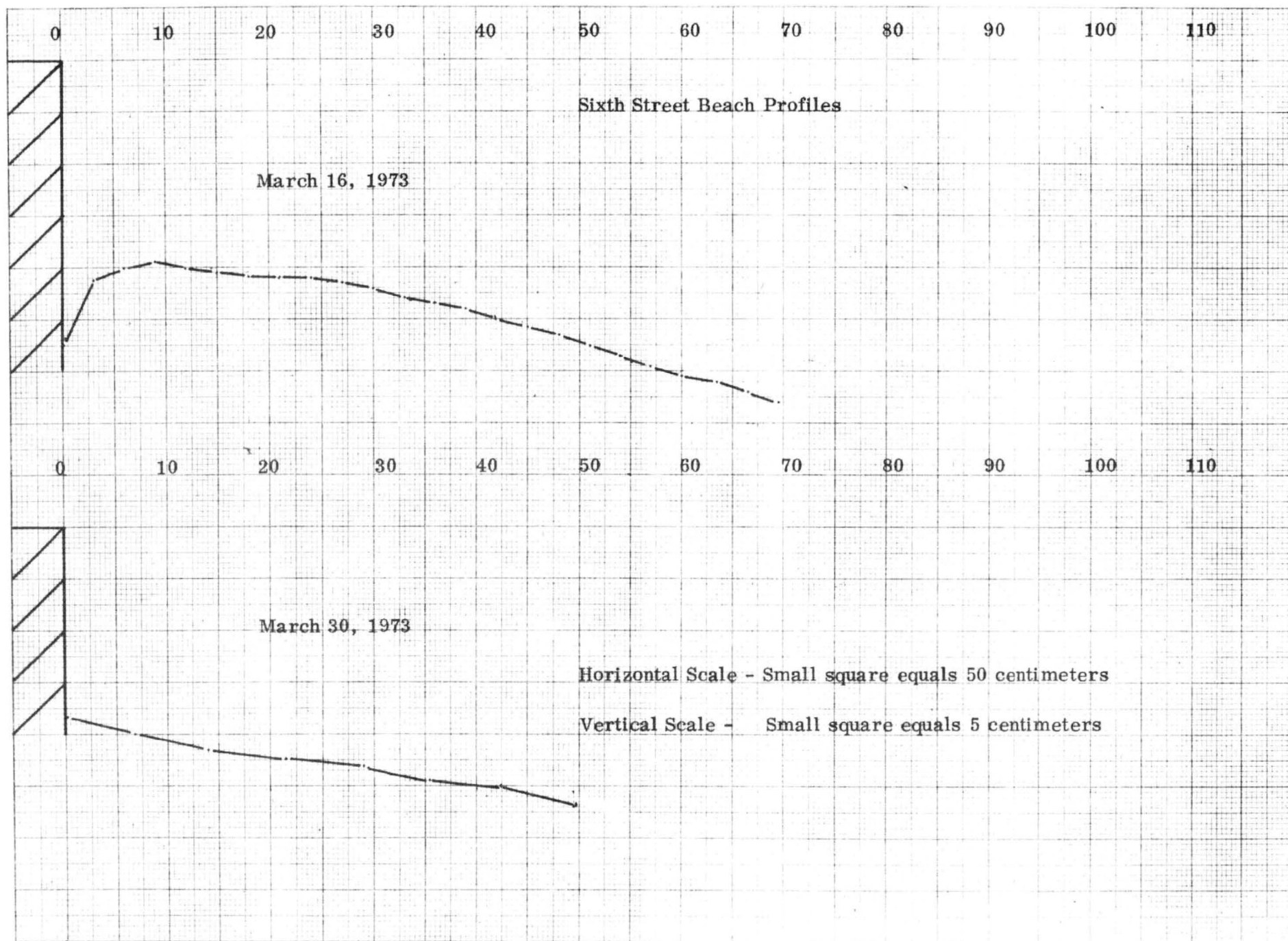
Horizontal Scale - Small square equals 50 centimeters

Vertical Scale -    Small square equals 5 centimeters

September 6, 1973

Sixth Street Beach Profile

September 25, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

42

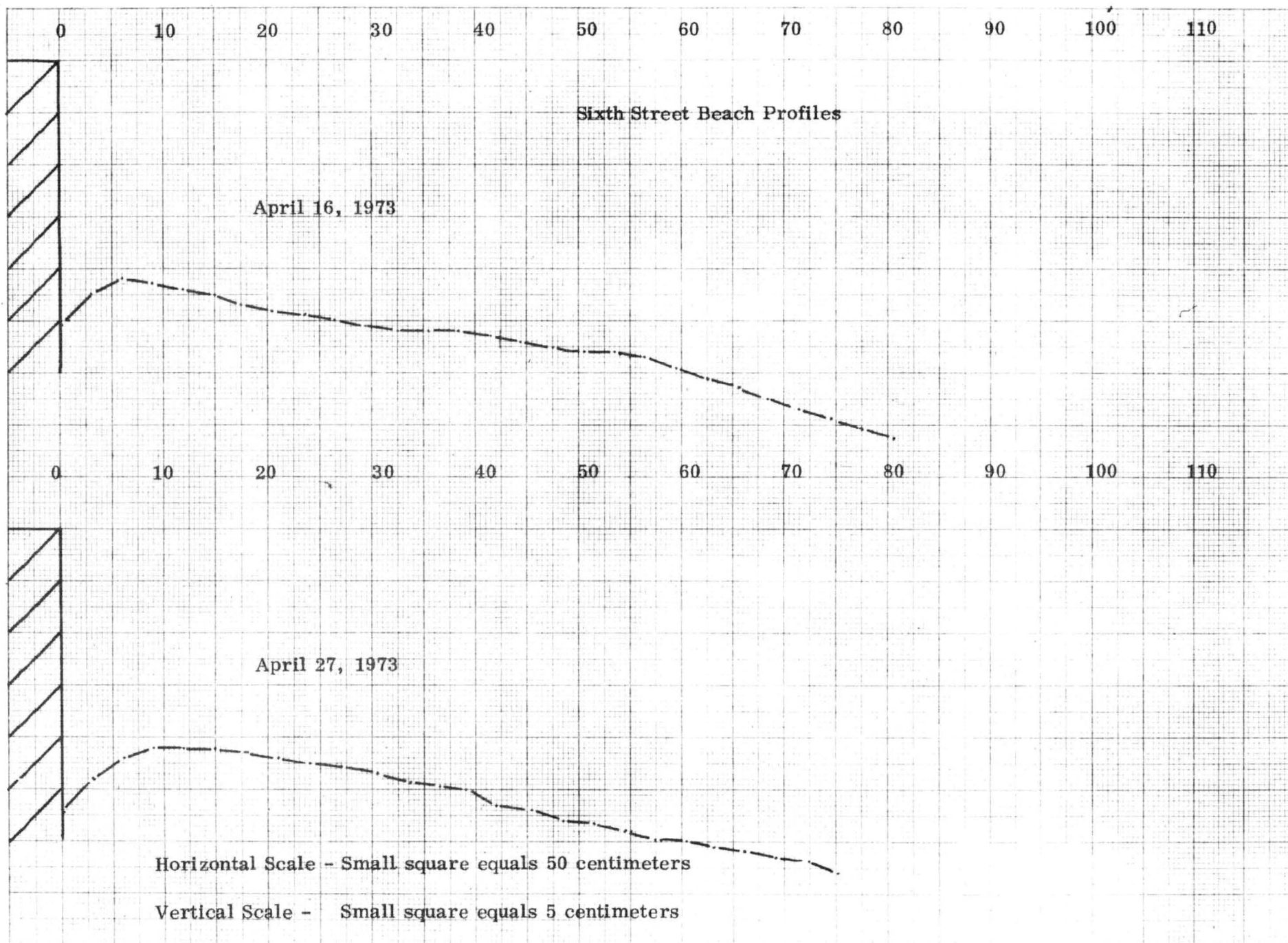October 8, 1973

Sixth Street Beach Profile

October 22, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale  – Small square equals 5 centimeters

43

Ninth Street Beach Profiles

# Ninth Street Beach Profiles

October 4, 1972

October 20, 1973

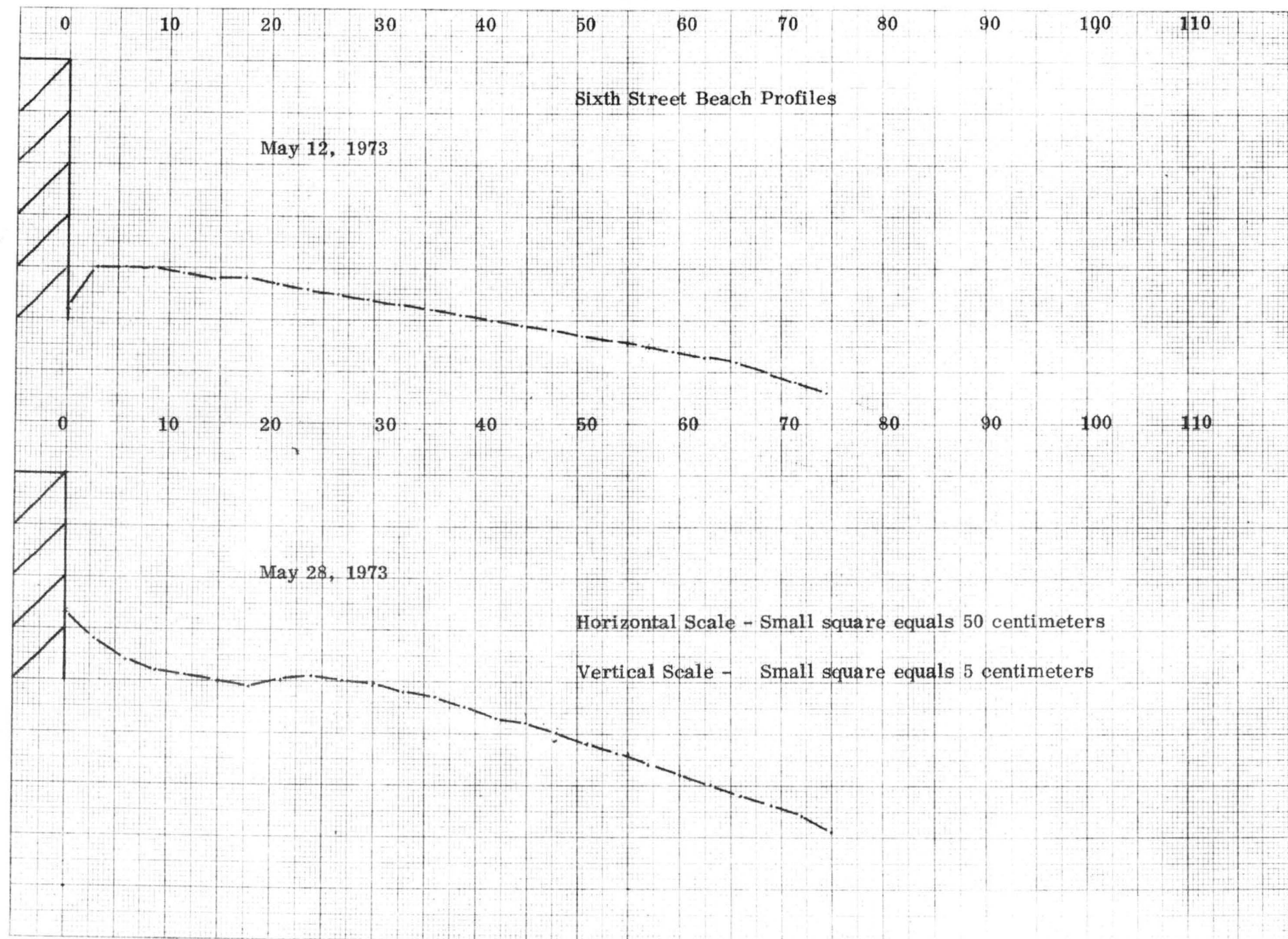Horizontal Scale –    Small square equals 50 centimeters

Vertical Scale –    Small square equals 5 centimeters

Ninth Street Beach Profiles

November 1, 1972

November 17, 1972

Horizontal Scale –    Small square equals 50 centimeters

Vertical Scale –    Small square equals 5 centimeters

Ninth Street Beach Profiles
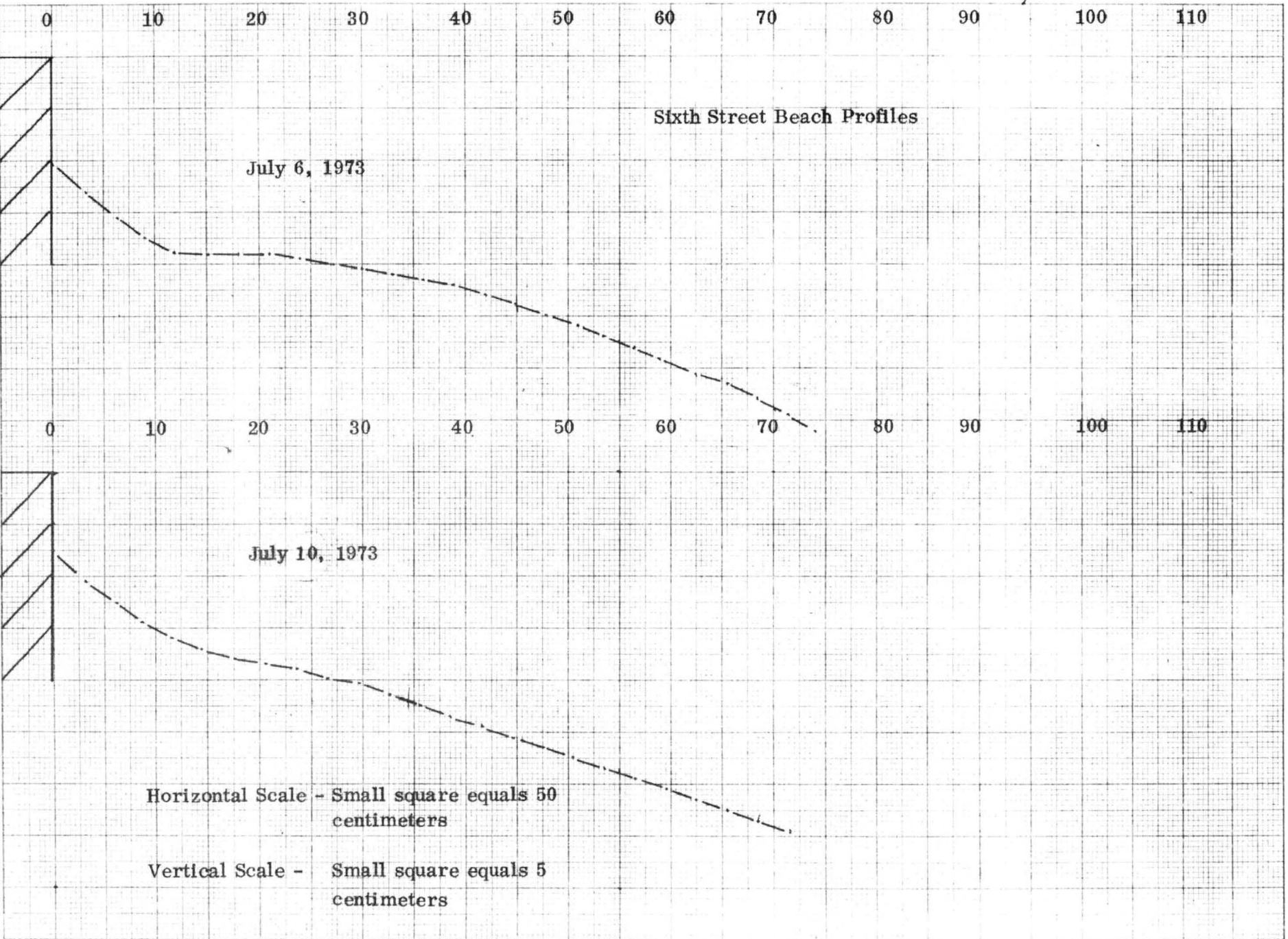
November 30, 1972

December 15, 1972

Horizontal Scale –    Small square equals 50 centimeters

Vertical Scale –    Small square equals 5 centimeters

# Ninth Street Beach Profiles

0    10    20    30    40    50    60    70    80

January 5, 1973

0    10    20    30    40    50    60    70    80

January 5, 1973

Horizontal Scale –    Small square equals 50 centimeters

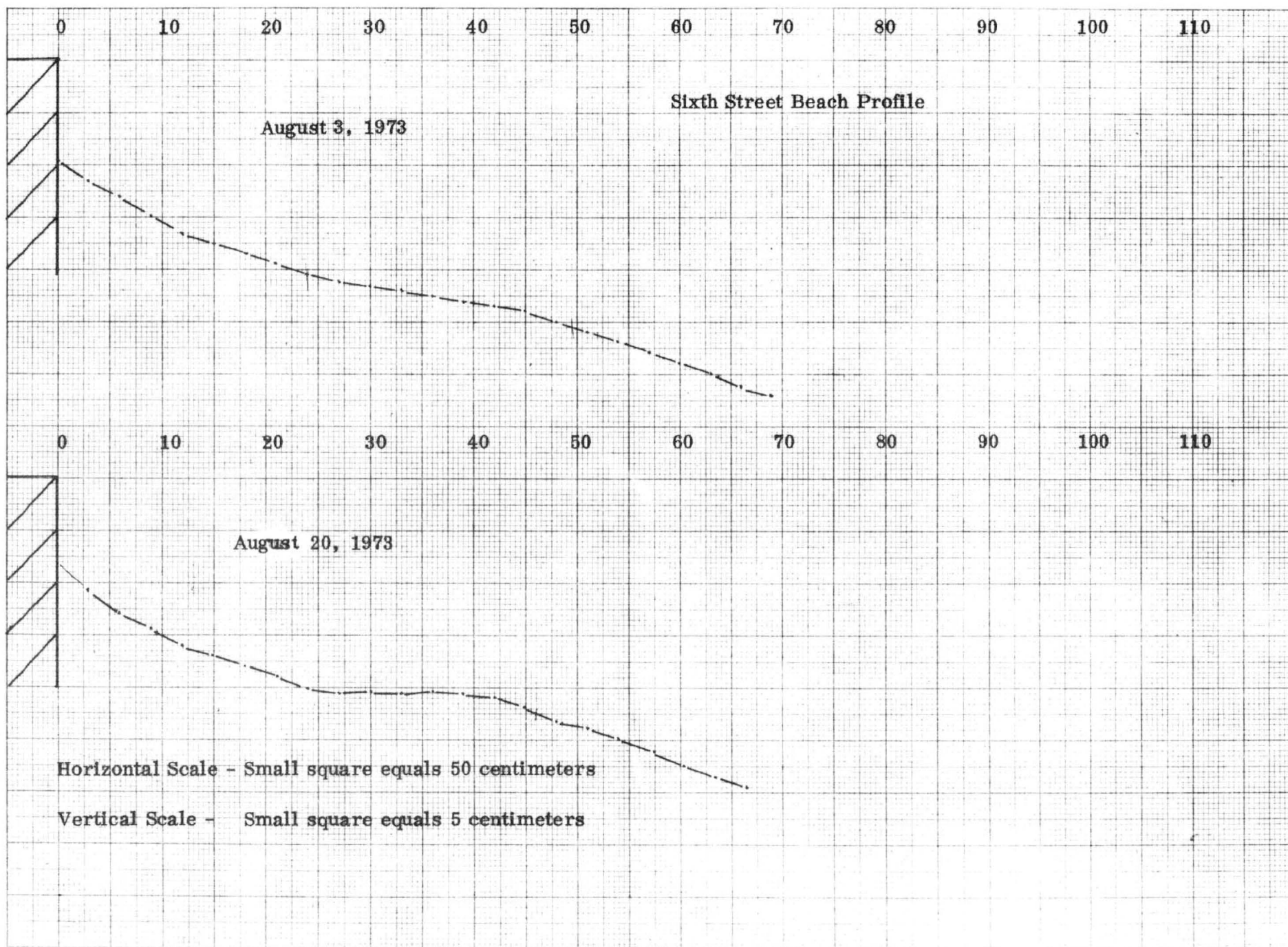Vertical Scale –    Small square equals 5 centimeters

# Ninth Street Beach Profiles

|  | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 |

February 3, 1973

|  | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 |

February 16, 1973

Horizontal Scale - Small square equals 50 centimeters

Vertical Scale -    Small square equals 5 centimeters

| 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 |
|---|----|----|----|----|----|----|----|----|----|-----|-----|

Ninth Street Beach Profiles

March 2, 1973

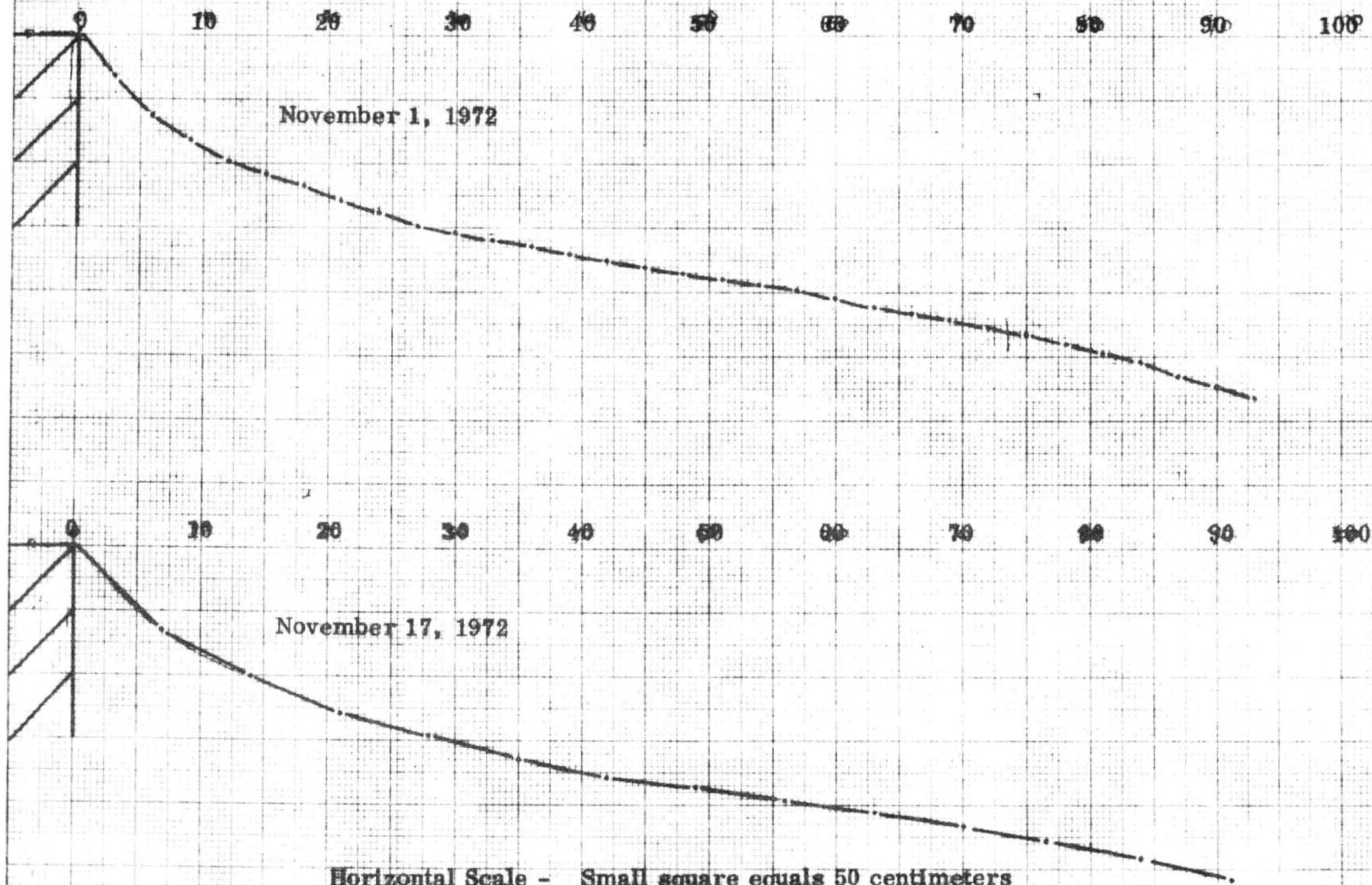Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Ninth Street Beach Profiles

March 16, 1973

March 30, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale –     Small square equals 5 centimeters

Ninth Street Beach Profiles

April 16, 1973

April 27, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Ninth Street Beach Profiles

May 12, 1973

May 28, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale –   Small square equals 5 centimeters

Ninth Street Beach Profiles

June 8, 1973

June 25, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Ninth Street Beach Profiles

July 6, 1973

July 20, 1973

Horizontal Scale - Small square equals 50 centimeters
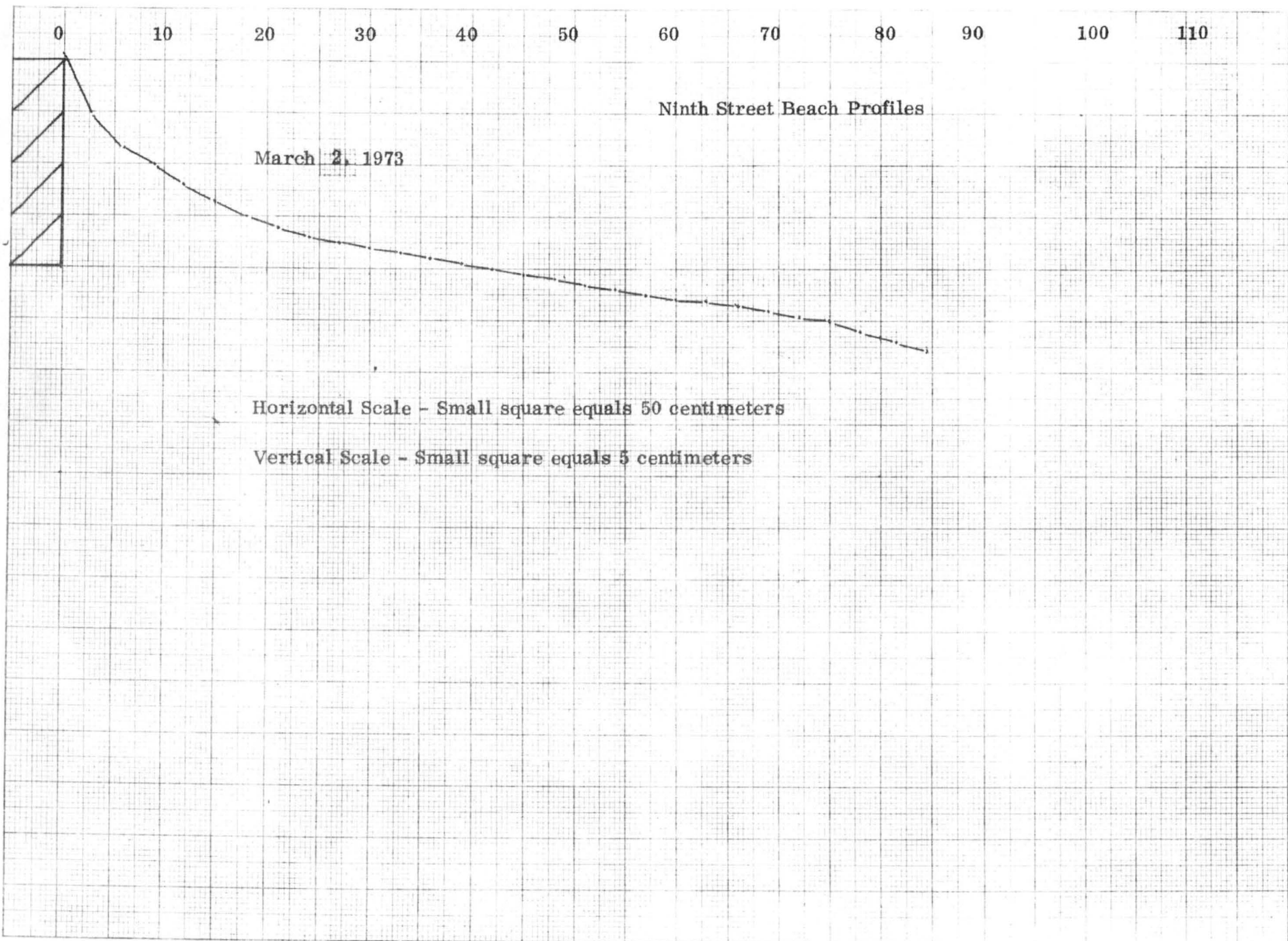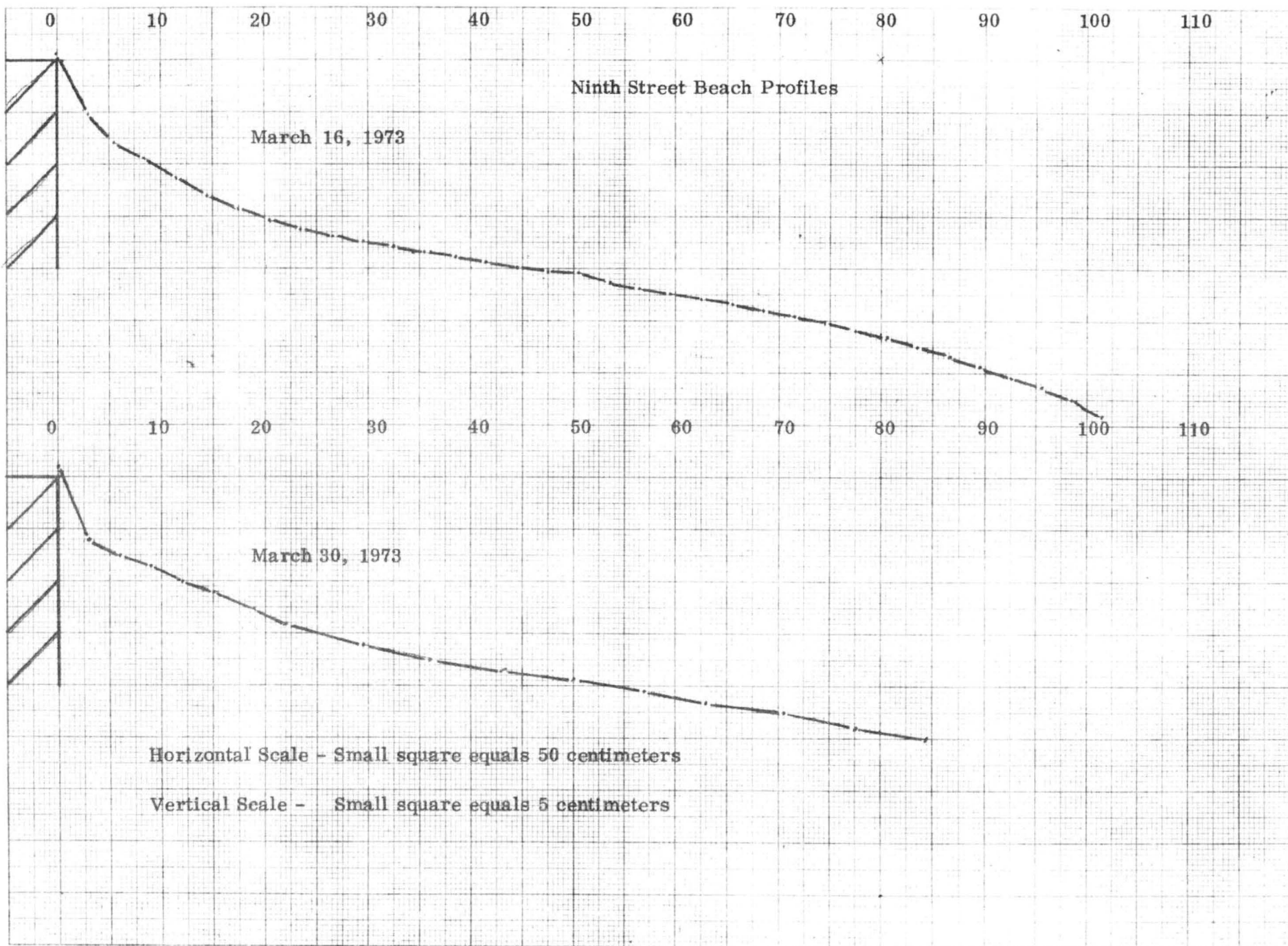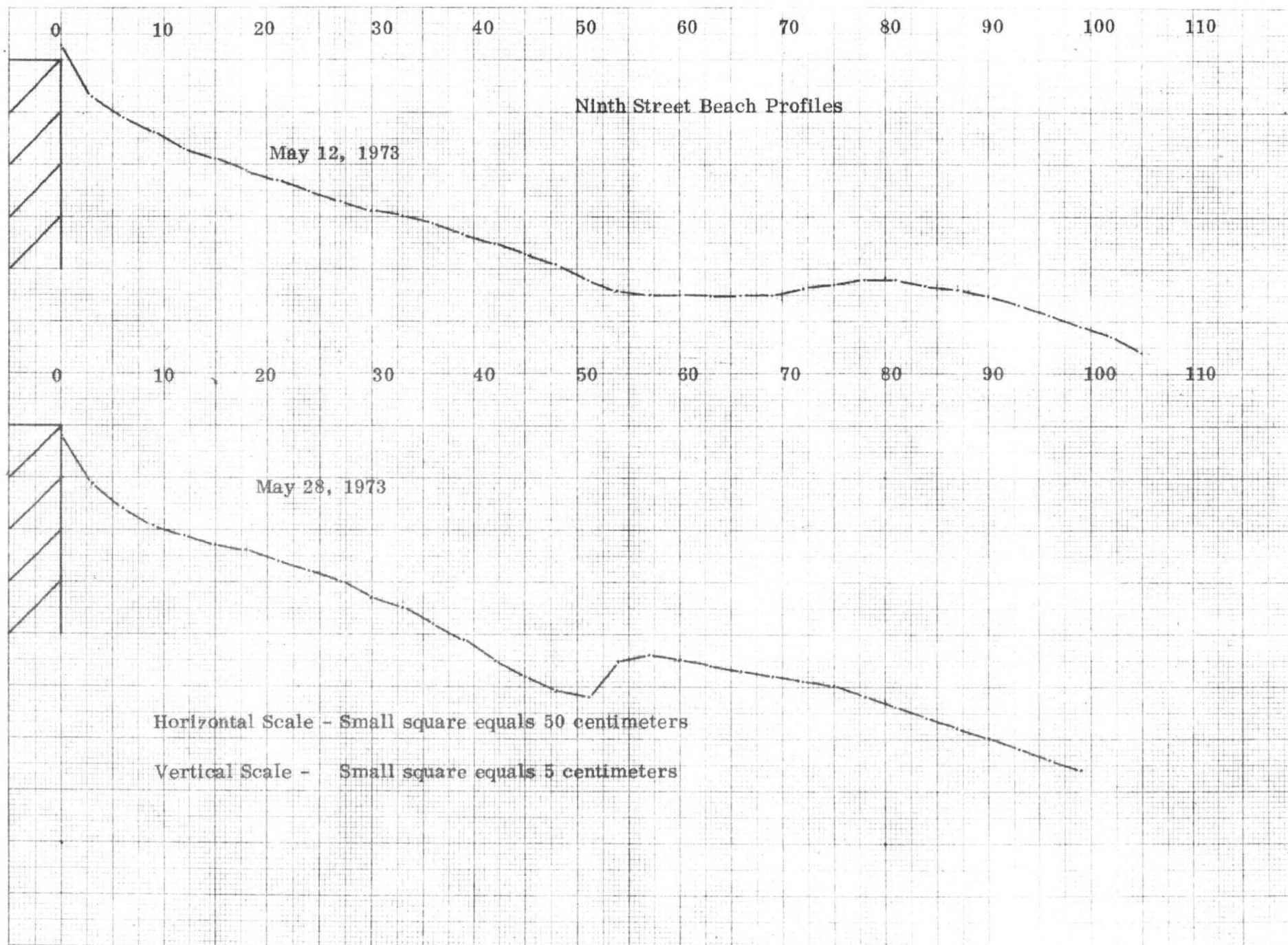
Vertical Scale -    Small square equals 5 centimeters

Ninth Street Profile

August 3, 1973

August 20, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Ninth Street Beach Profile

September 6, 1973

September 25, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale –   Small square equals 5 centimeters

Ninth Street Beach Profile

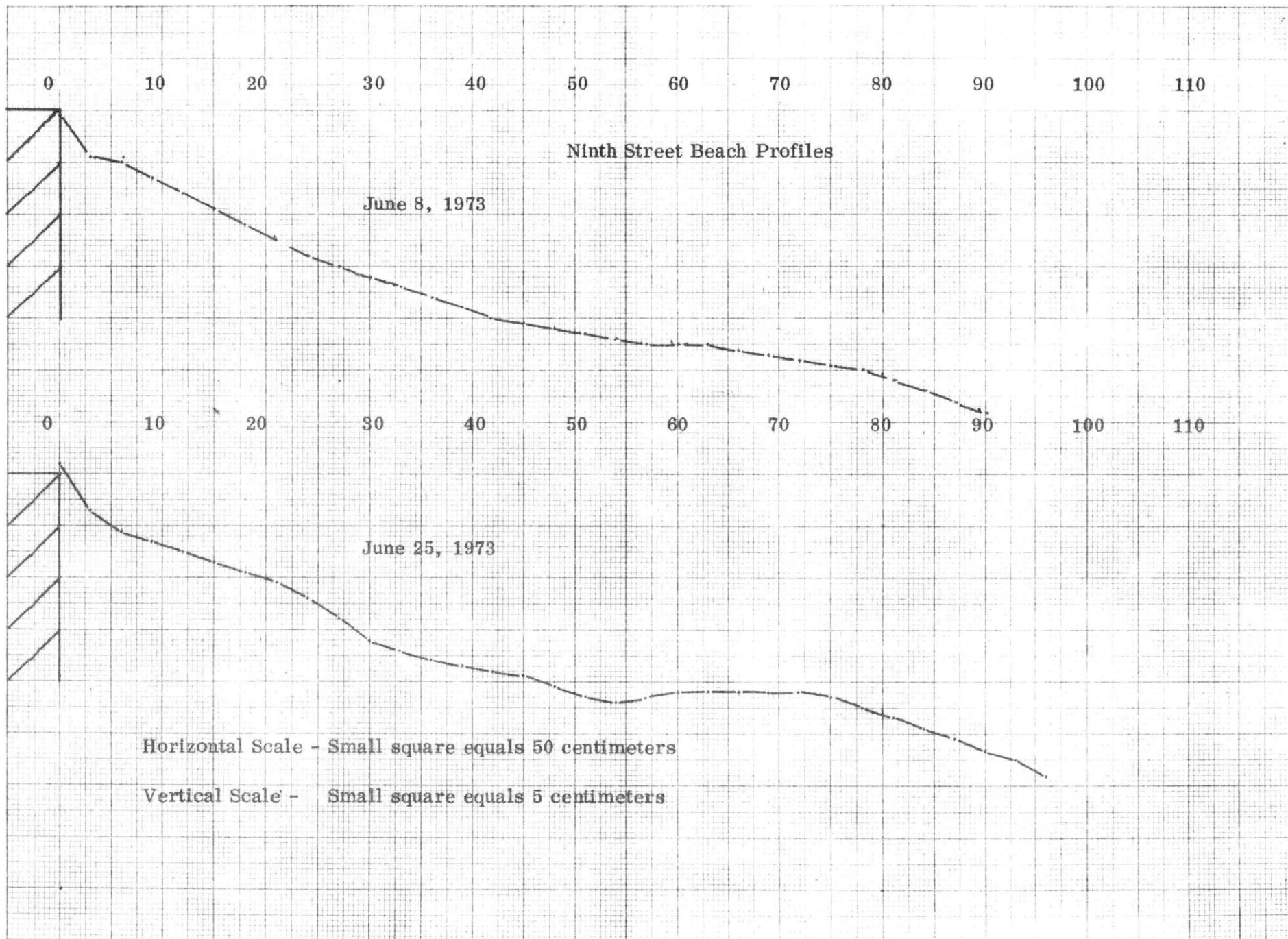October 8, 1973

October 22, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Twelfth Street Beach Profiles

# Twelfth Street Beach Profiles

October 4, 1972

0     10     20     30     40     50     60     70     80     90     100     110

October 20, 1972

Horizontal Scale -    Small square equals 50 centimeters

Vertical Scale -    Small square equals 5 centimeters

# Twelfth Street Beach Profiles

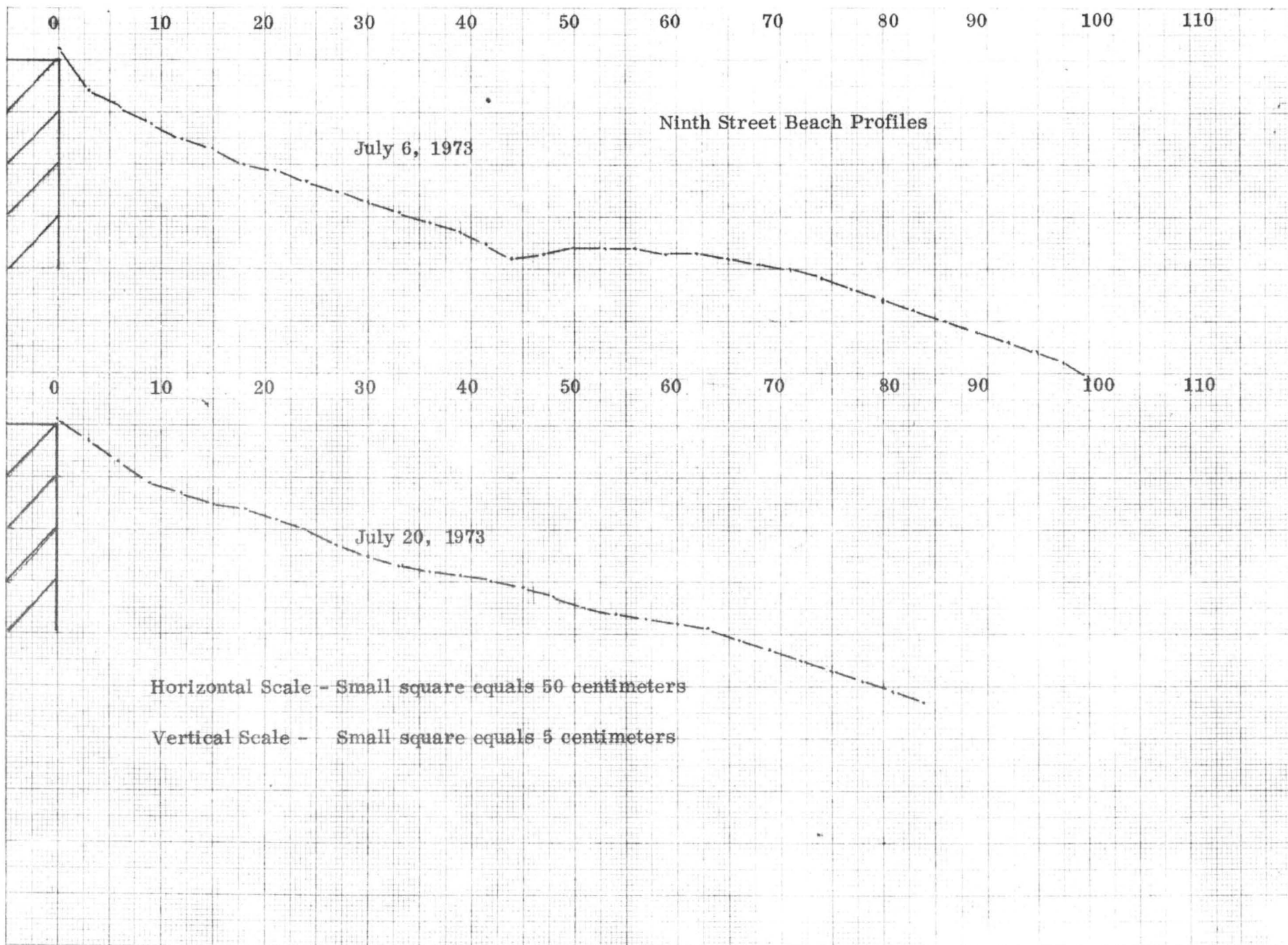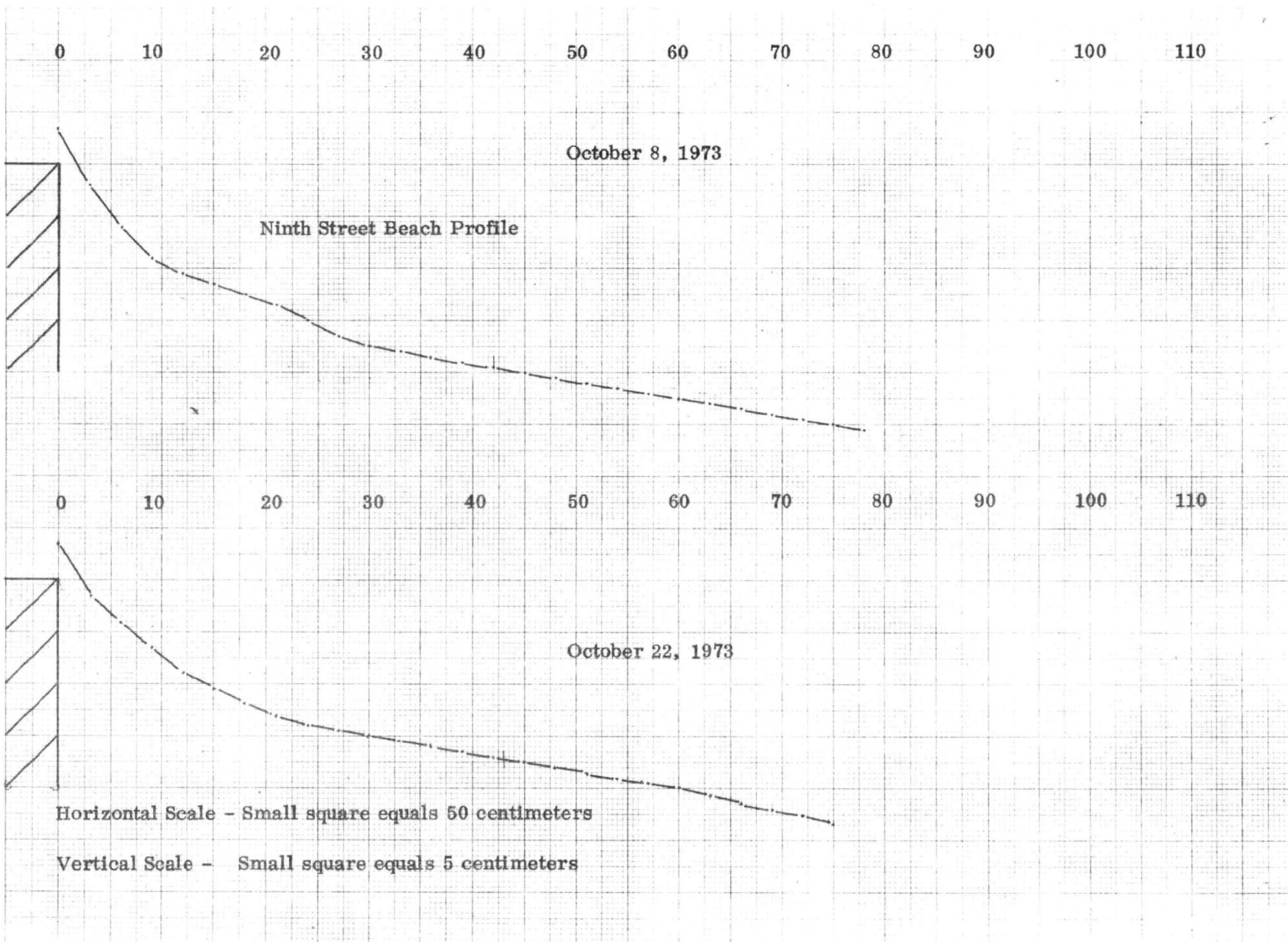November 1, 1972

November 17, 1972

Horizontal Scale -  Small square equals 50 centimeters

Vertical Scale -  Small square equals 5 centimeters

Twelfth Street Beach Profiles

November 30, 1972

December 15, 1972

Horizontal Scale –    Small square equals 50 centimeters

Vertical Scale –    Small square equals 5 centimeters

Twelfth Street Beach Profiles

0        10        20        30        40        50        60        70        80        90        100

January 5, 1973

0        10        20        30        40        50        60        70        80        90        100
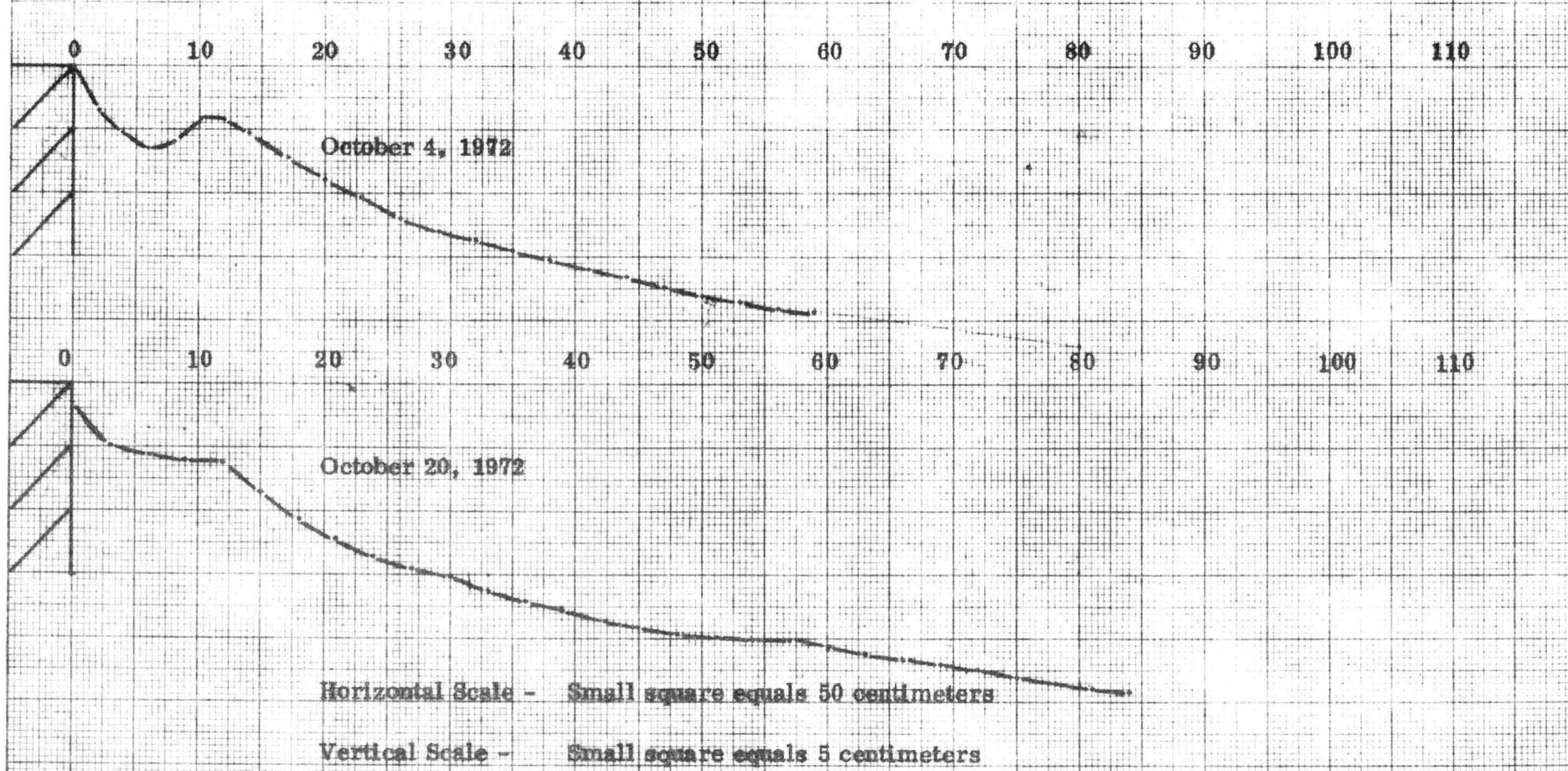
January 19, 1973

Horizontal Scale –    Small square equals 50 centimeters

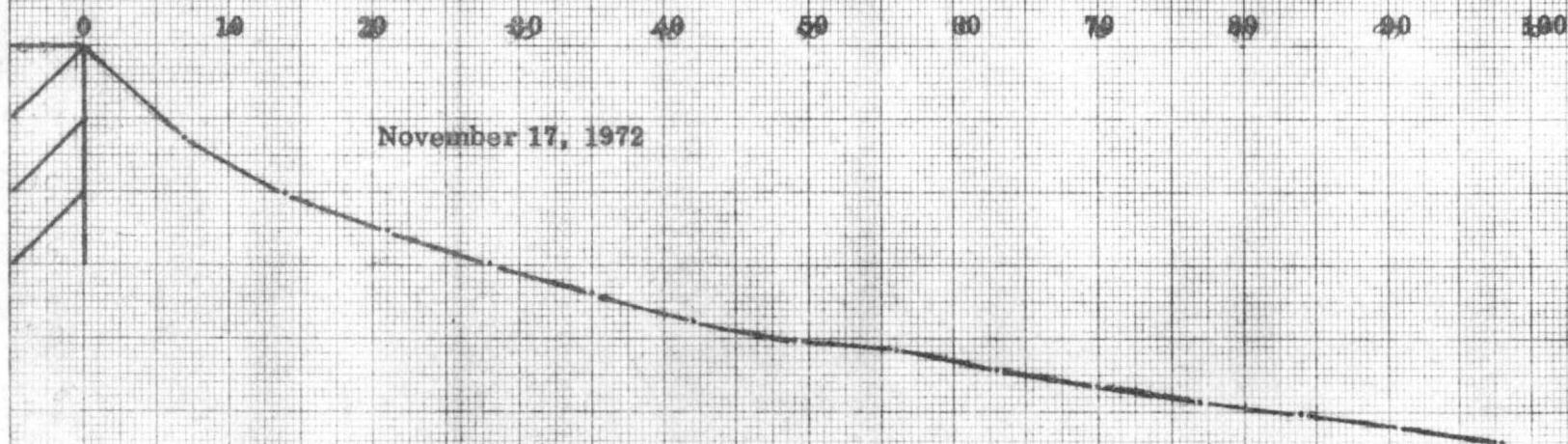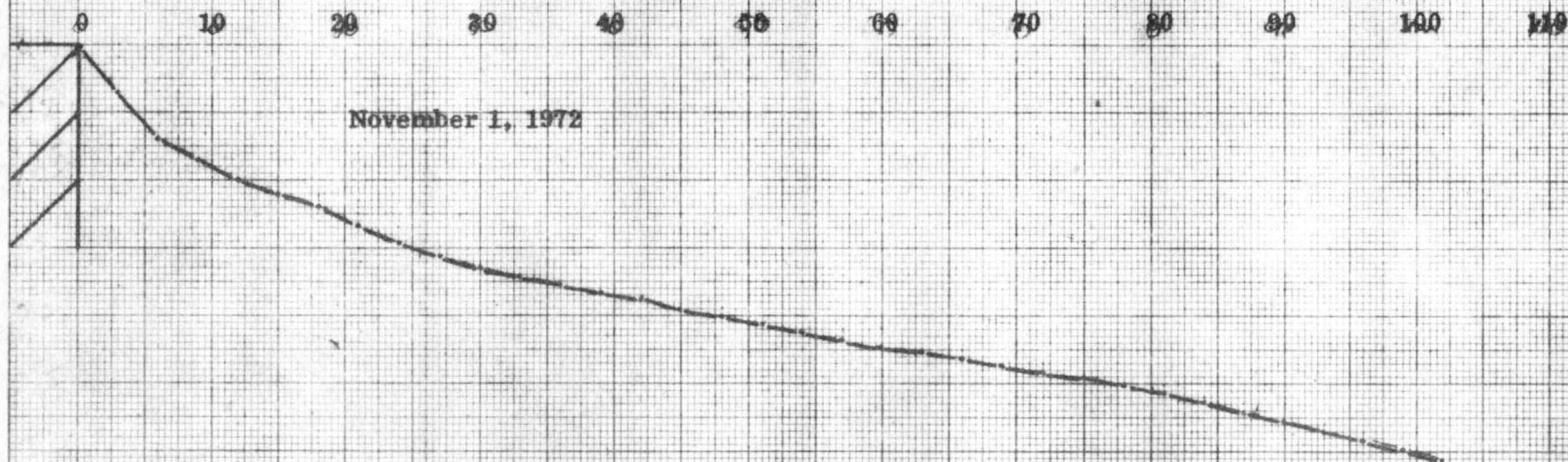Vertical Scale –      Small square equals 5 centimeters

Twelfth Street Beach Profiles

February 3, 1973

February 16, 1973

Horizontal Scale —    Small square equals 50 centimeters

Vertical Scale —    Small square equals 5 centimeters

Twelfth Street Beach Profiles

March 2, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Twelfth Street Beach Profiles

March 16, 1973

March 30, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Twelfth Street Beach Profiles

April 16, 1973

April 27, 1973
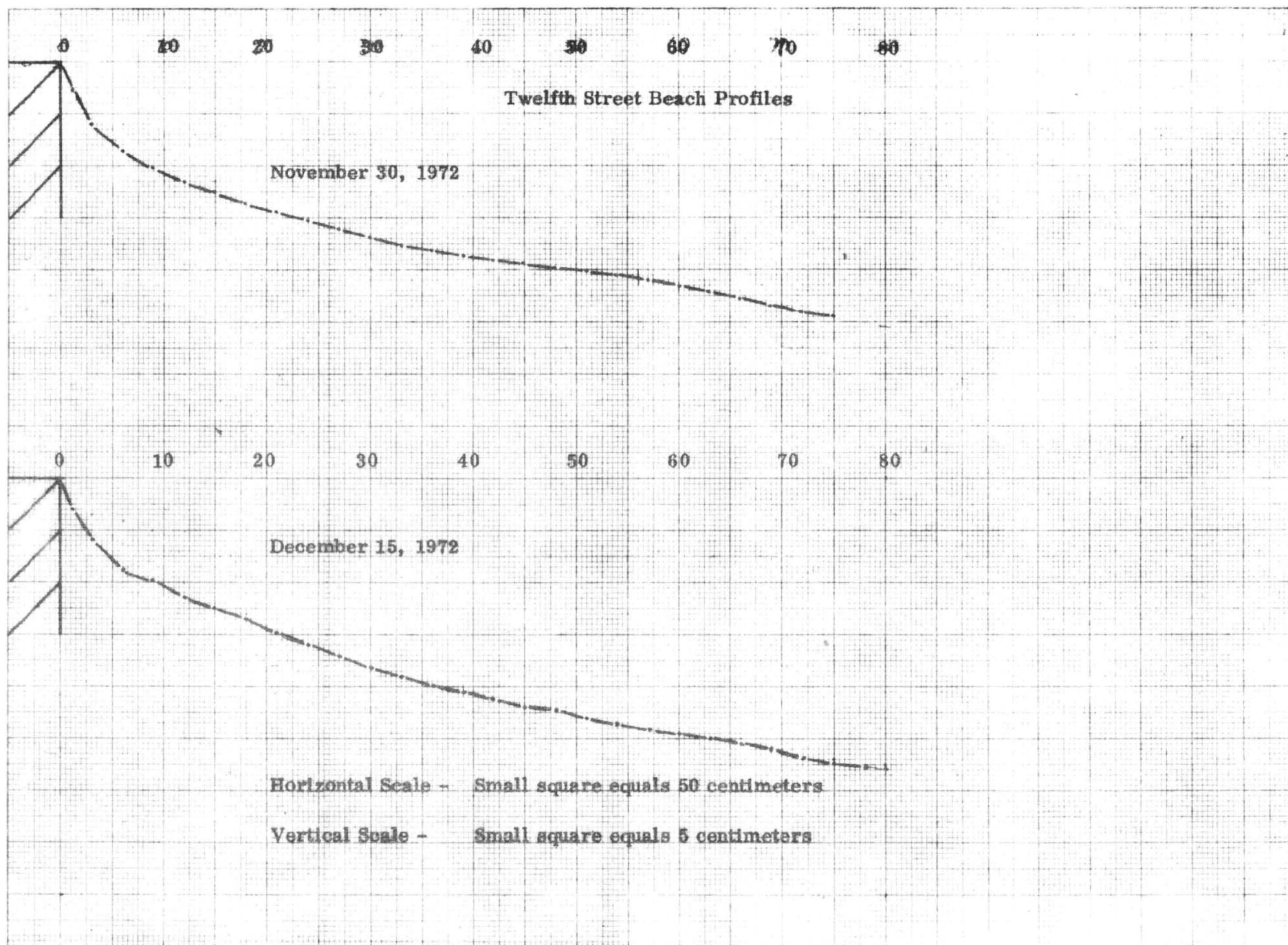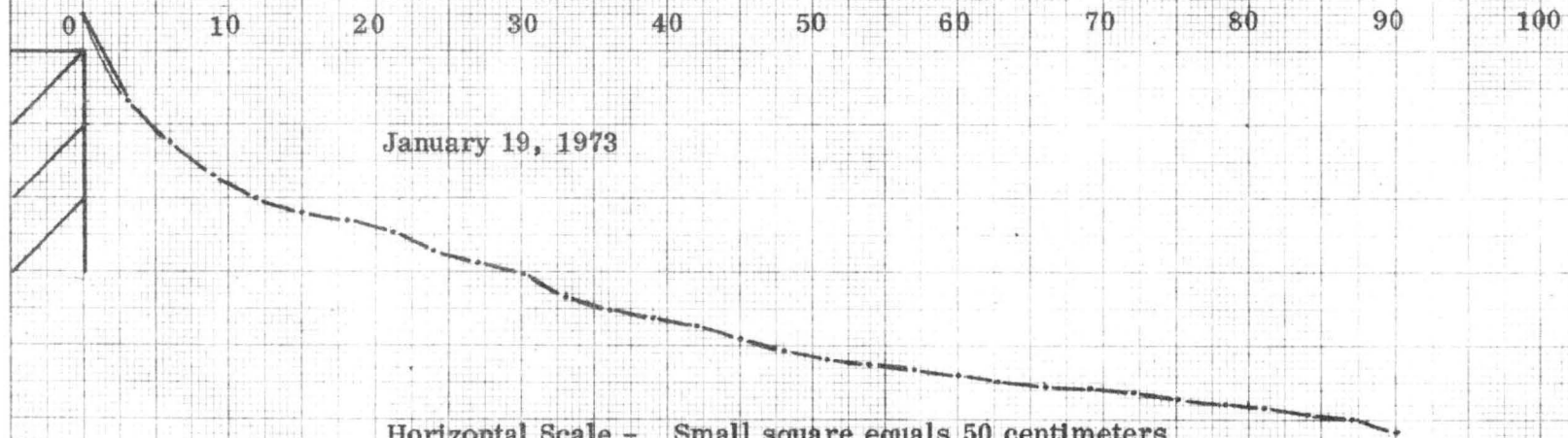
Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Twelfth Street Beach Profile

May 12, 1973

May 28, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale –   Small square equals 5 centimeters
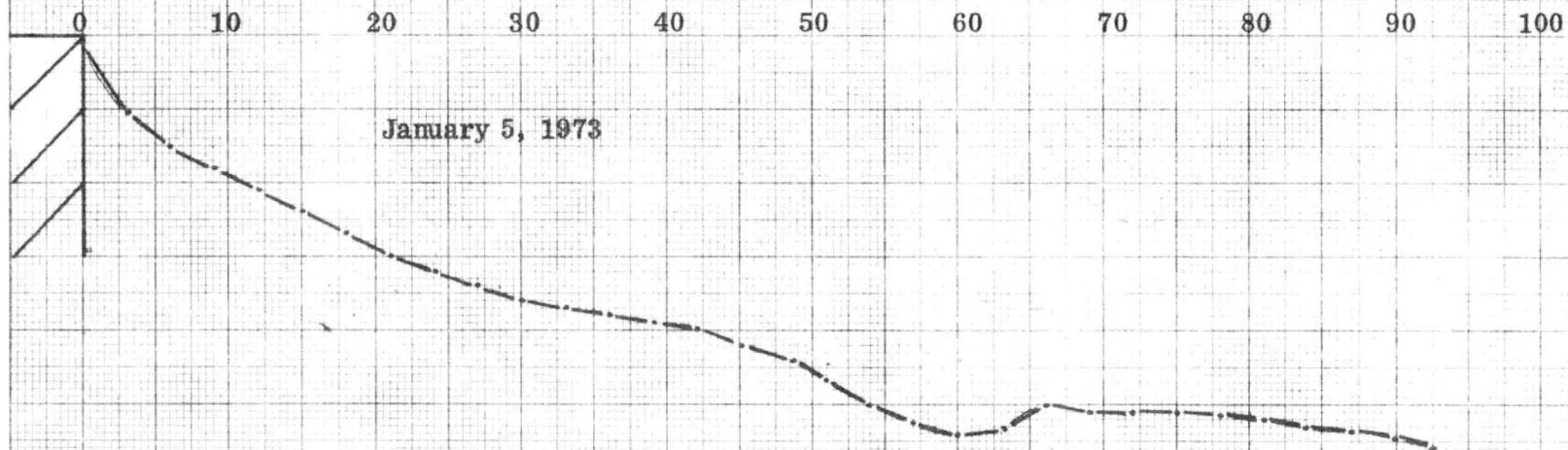
Twelfth Street Beach Profile

June 8, 1973

June 25, 1973

Horizontal Scale - Small square equals 50 centimeters

Vertical Scale -  Small square equals 5 centimeters

Twelfth Street Beach Profiles

July 6, 1973

July 20, 1973

Horizontal Scale – Small square equals 50 centimeters
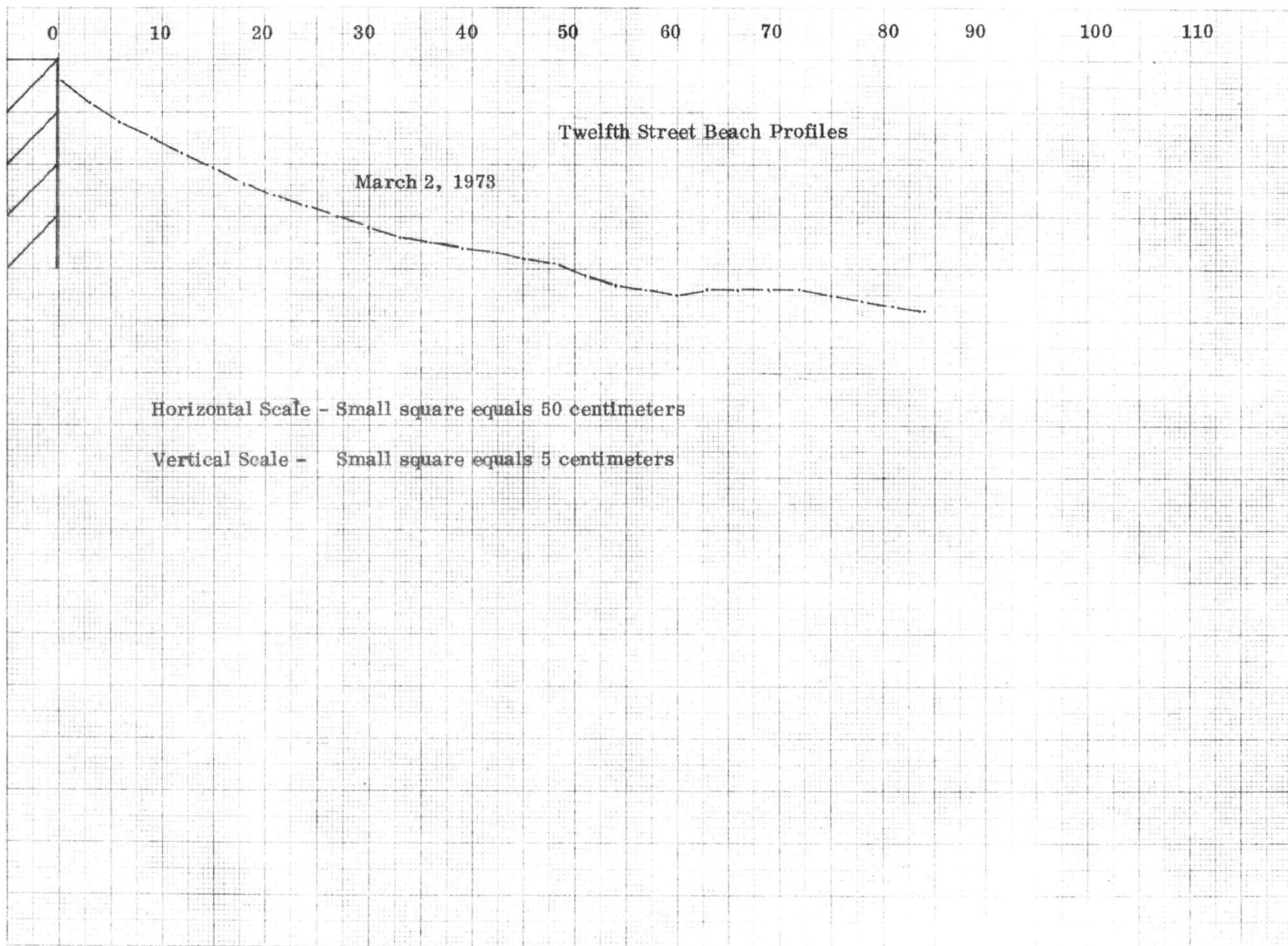
Vertical Scale –     Small square equals 5 centimeters

Twelfth Street Beach Profile

August 3, 1973

August 20, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Twelfth Street Beach Profile

September 6, 1973

September 25, 1973

Horizontal Scale – Small square equals 50 centimeters

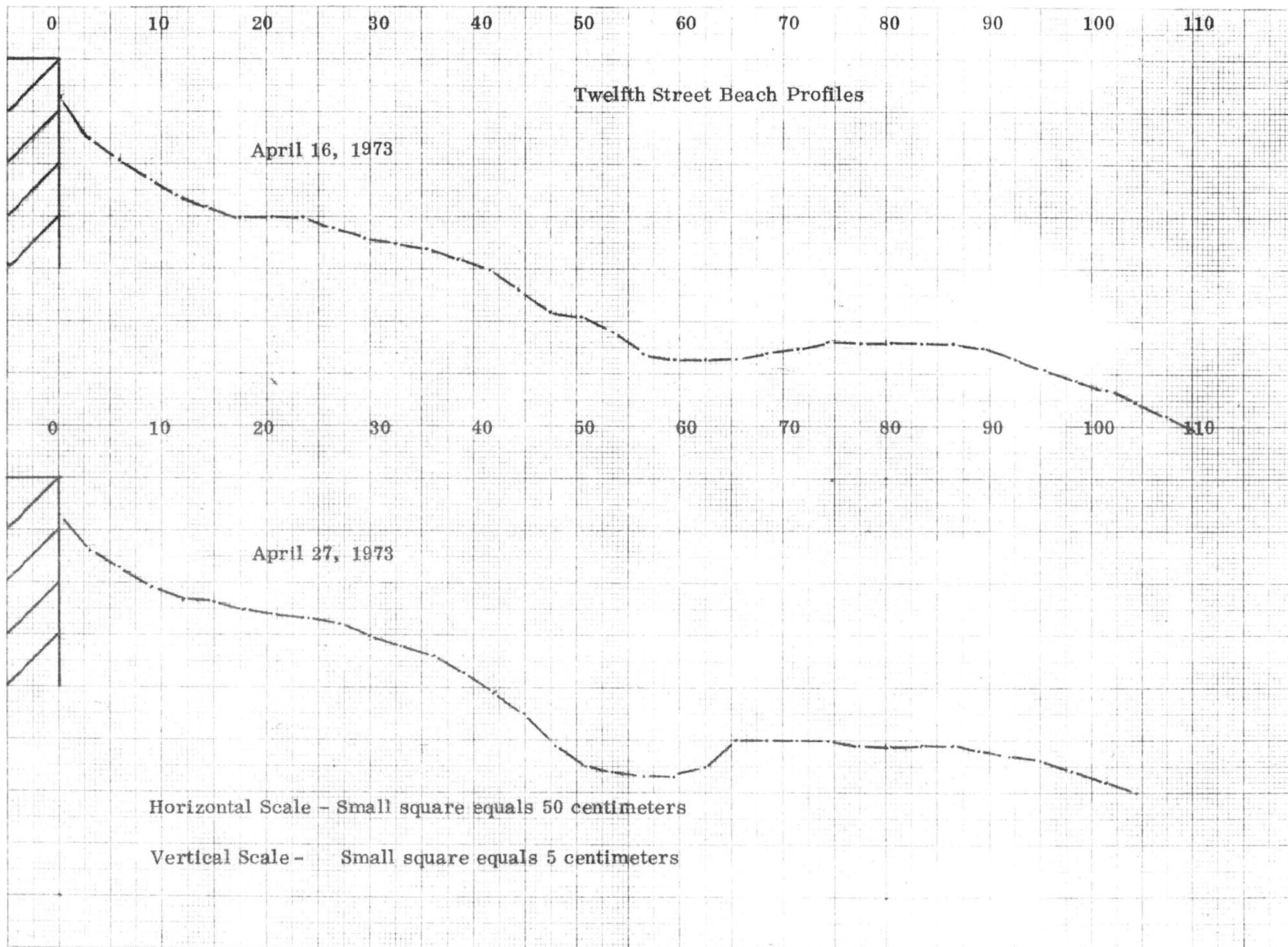Vertical Scale –   Small square equals 5 centimeters

October 8, 1973

Twelfth Street Beach Profile

October 22, 1973

Horizontal Scale – Small square equals 50 centimeters

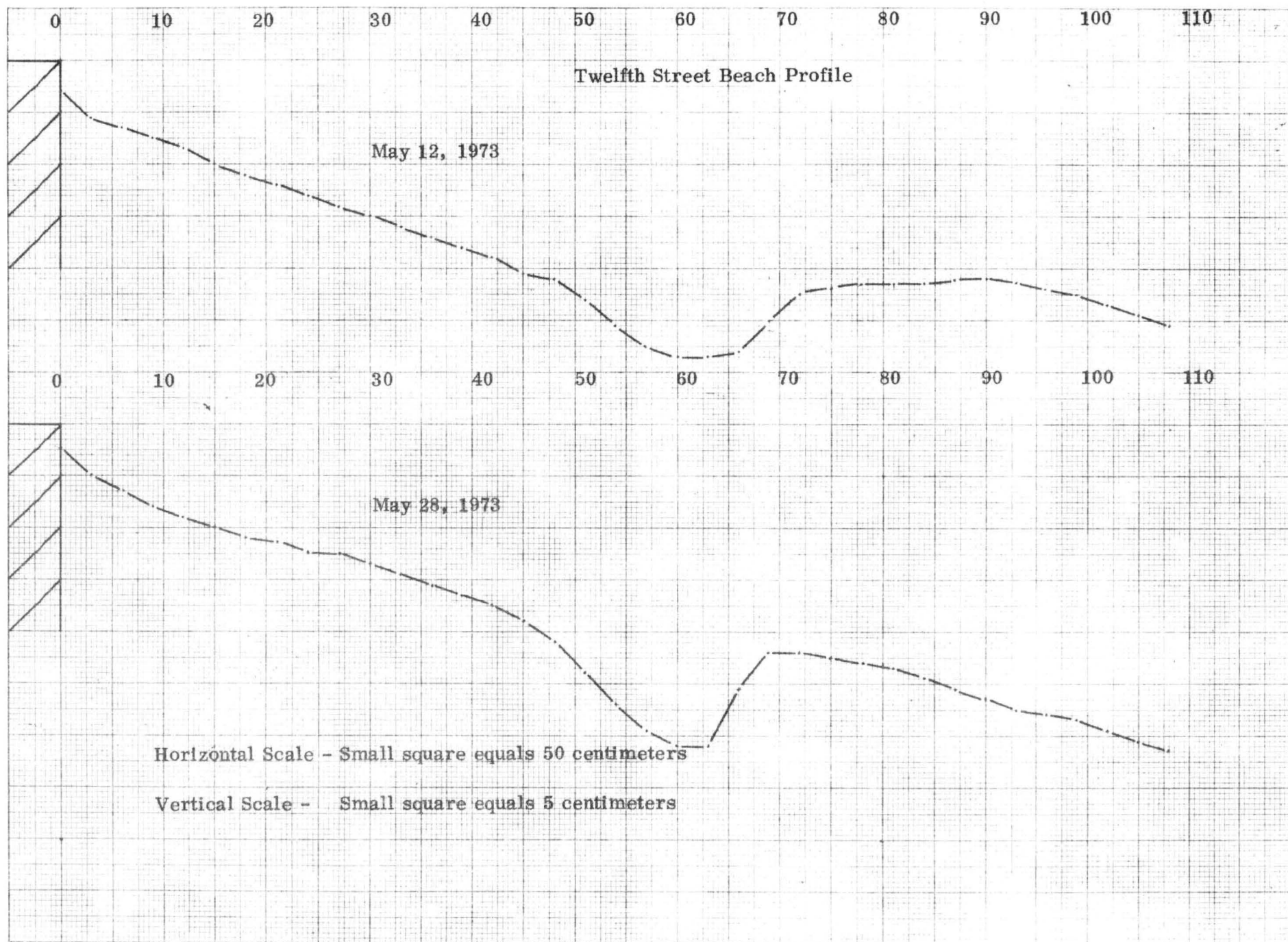Vertical Scale –   Small square equals 5 centimeters

Sixteenth Street Beach Profiles

# Sixteenth Street Beach Profiles

0    10    20    30    40    50    60    70    80    90    100    110

October 4, 1972

0    10    20    30    40    50    60    70    80    90    100    110

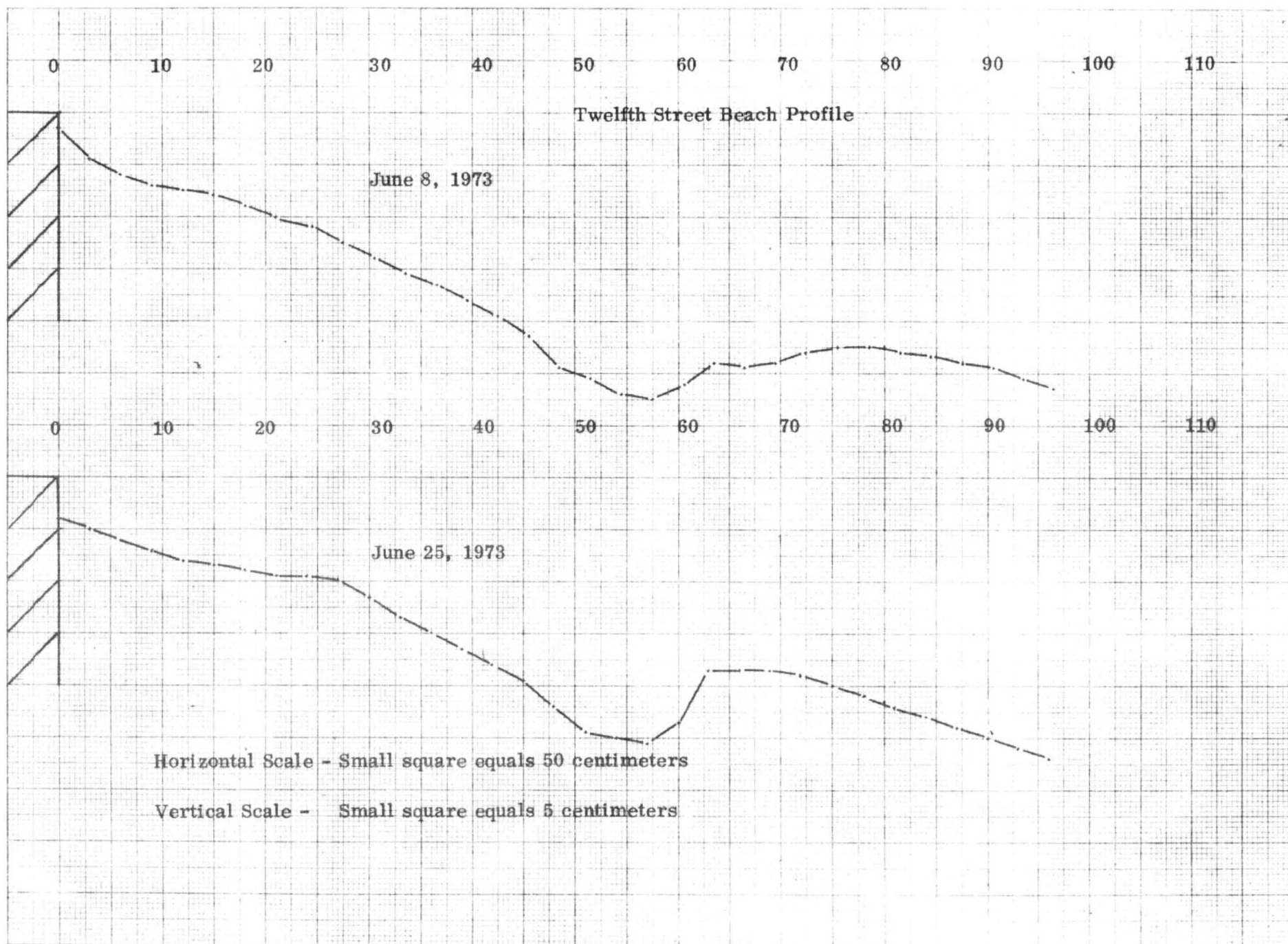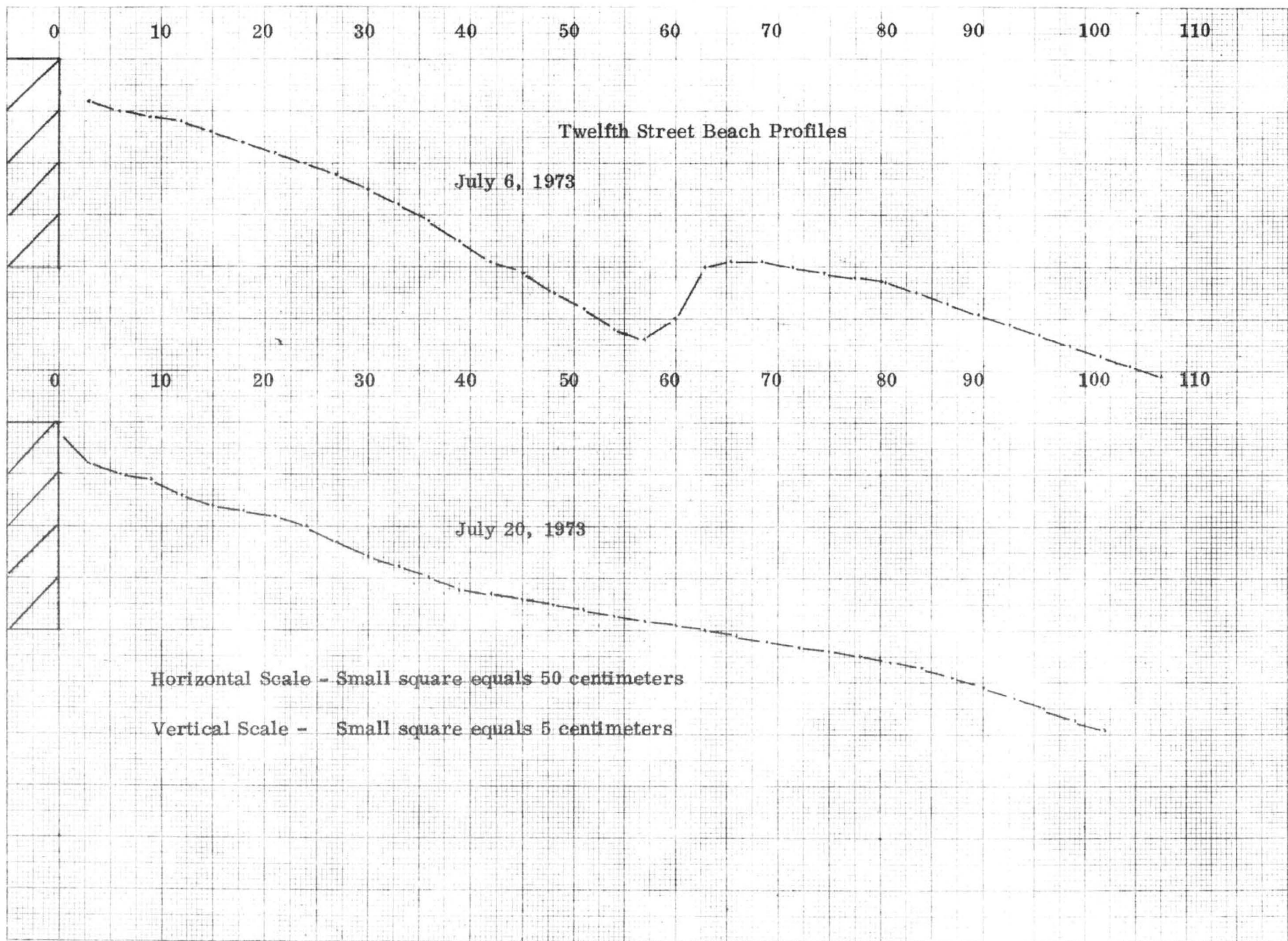October 4, 1972

Horizontal Scale –    Small square equals 50 centimeters

Vertical Scale –    Small square equals 5 centimeters

# Sixteenth Street Beach Profiles

| 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 |

November 1, 1972

| 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 110 |

November 17, 1972

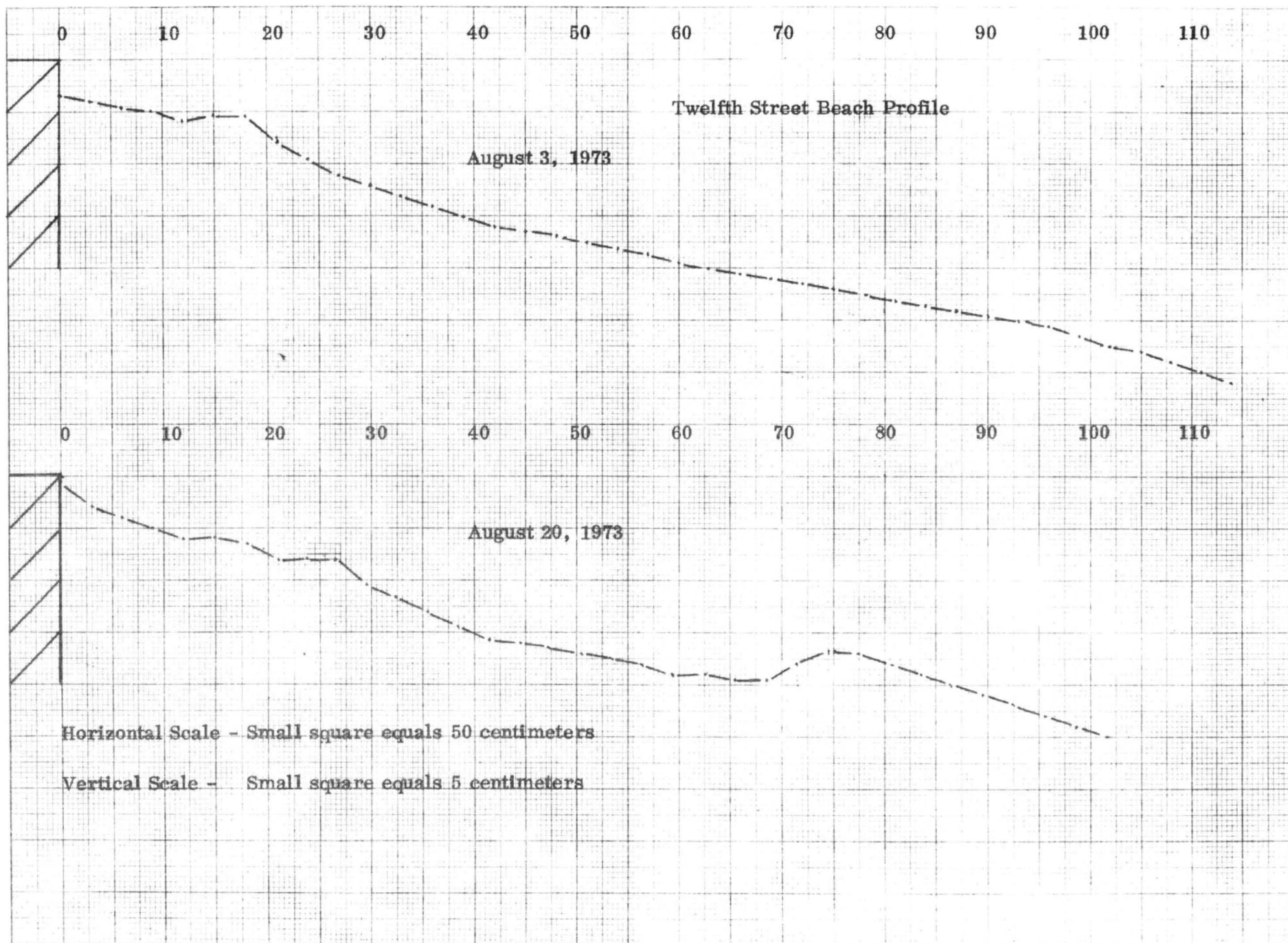Horizontal Scale –     Small square equals 50 centimeters
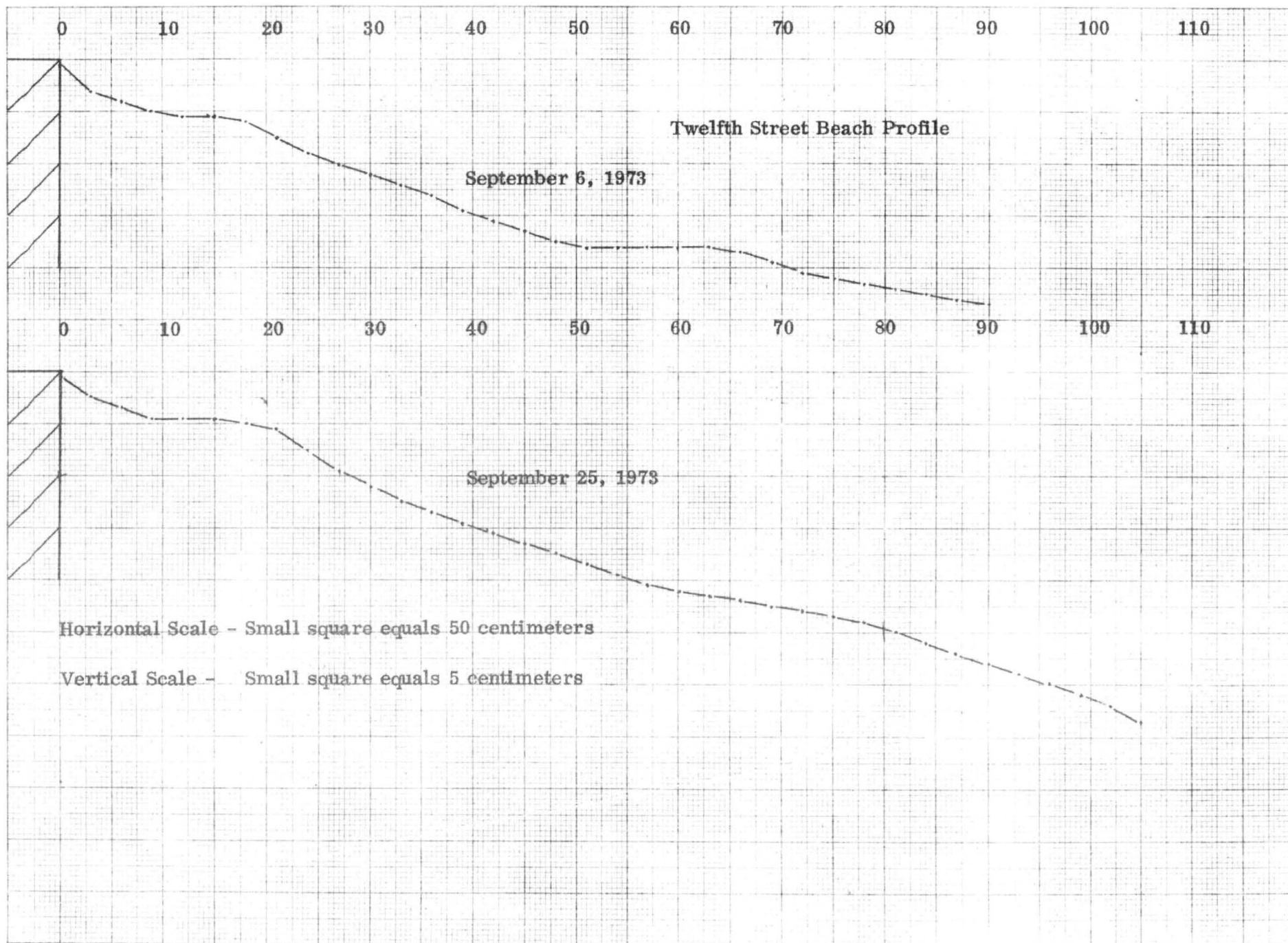
Vertical Scale –     Small square equals 5 centimeters

Sixteenth Street Beach Profiles

November 30, 1972

December 15, 1972

Horizontal Scale — Small square equals 50 centimeters

Vertical Scale — Small square equals 5 centimeters

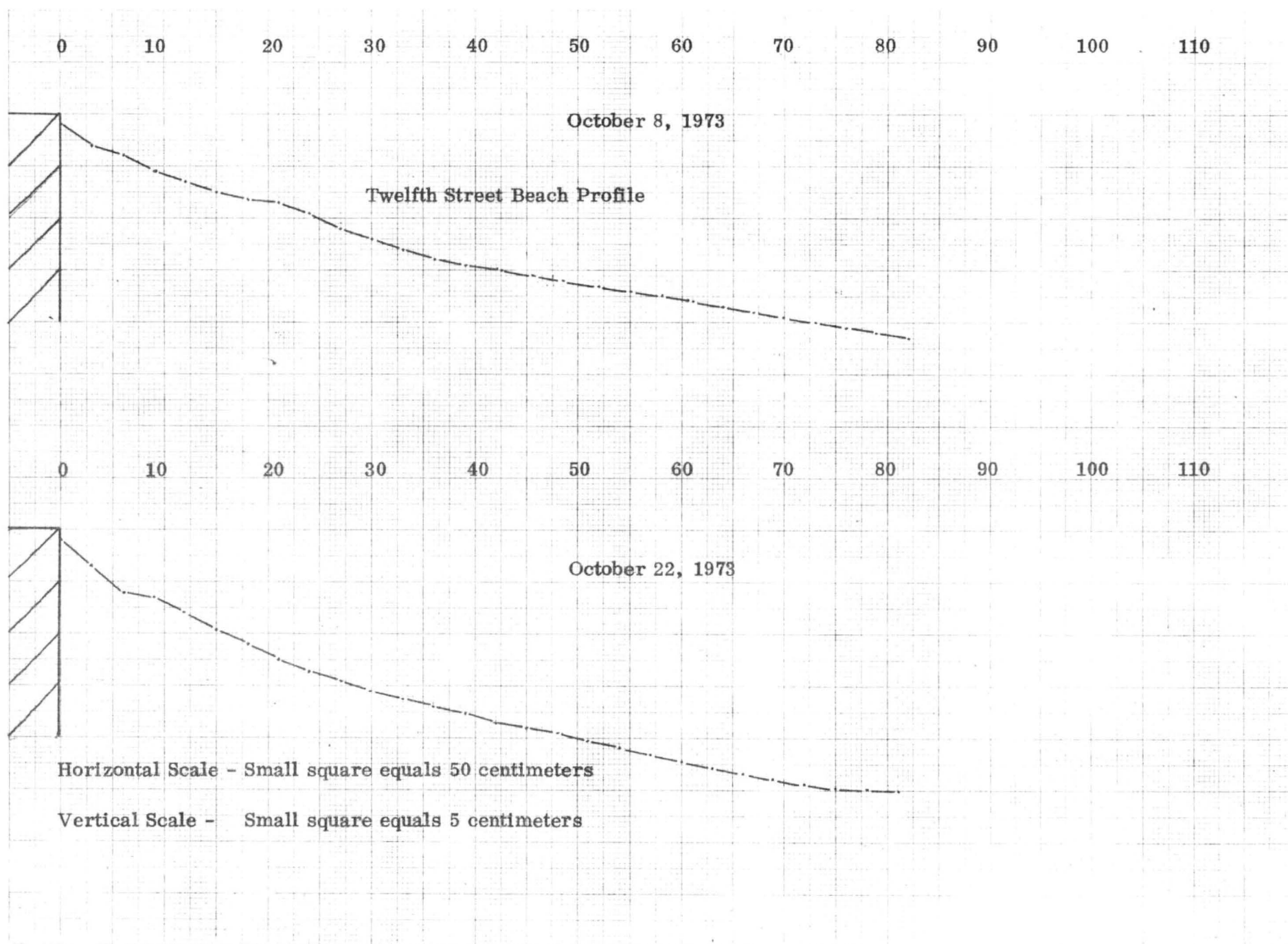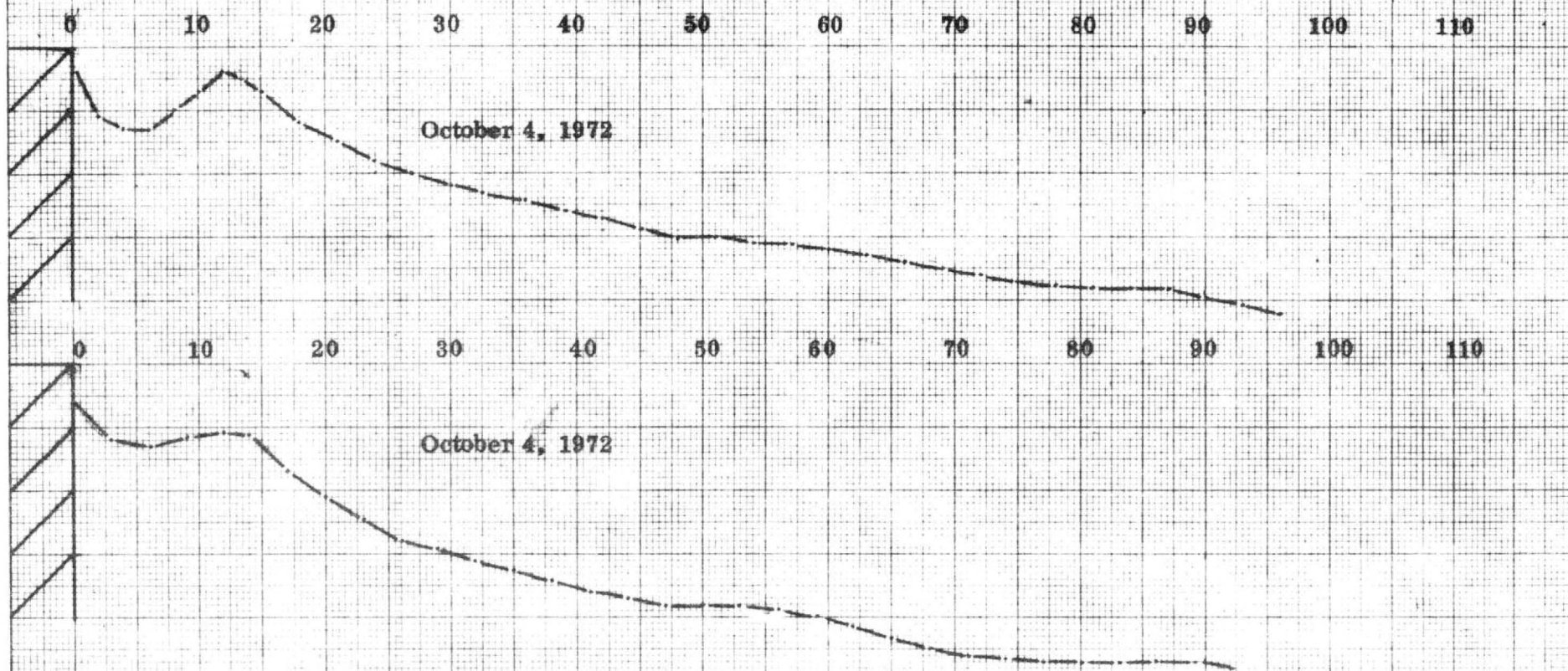Sixteenth Street Beach Profiles

January 5, 1973

January 17, 1973

Horizontal Scale —  Small square equals 50 centimeters

Vertical Scale —  Small square equals 5 centimeters

# Sixteenth Street Beach Profiles

0    10    20    30    40    50    60    70    80    90    100    110    120

February 5, 1973

0    10    20    30    40    50    60    70    80 .    90    100    110    120

February 16, 1973

Horizontal Scale –    Small square equals 50 centimeters

Vertical Scale –    Small square equals 5 centimeters
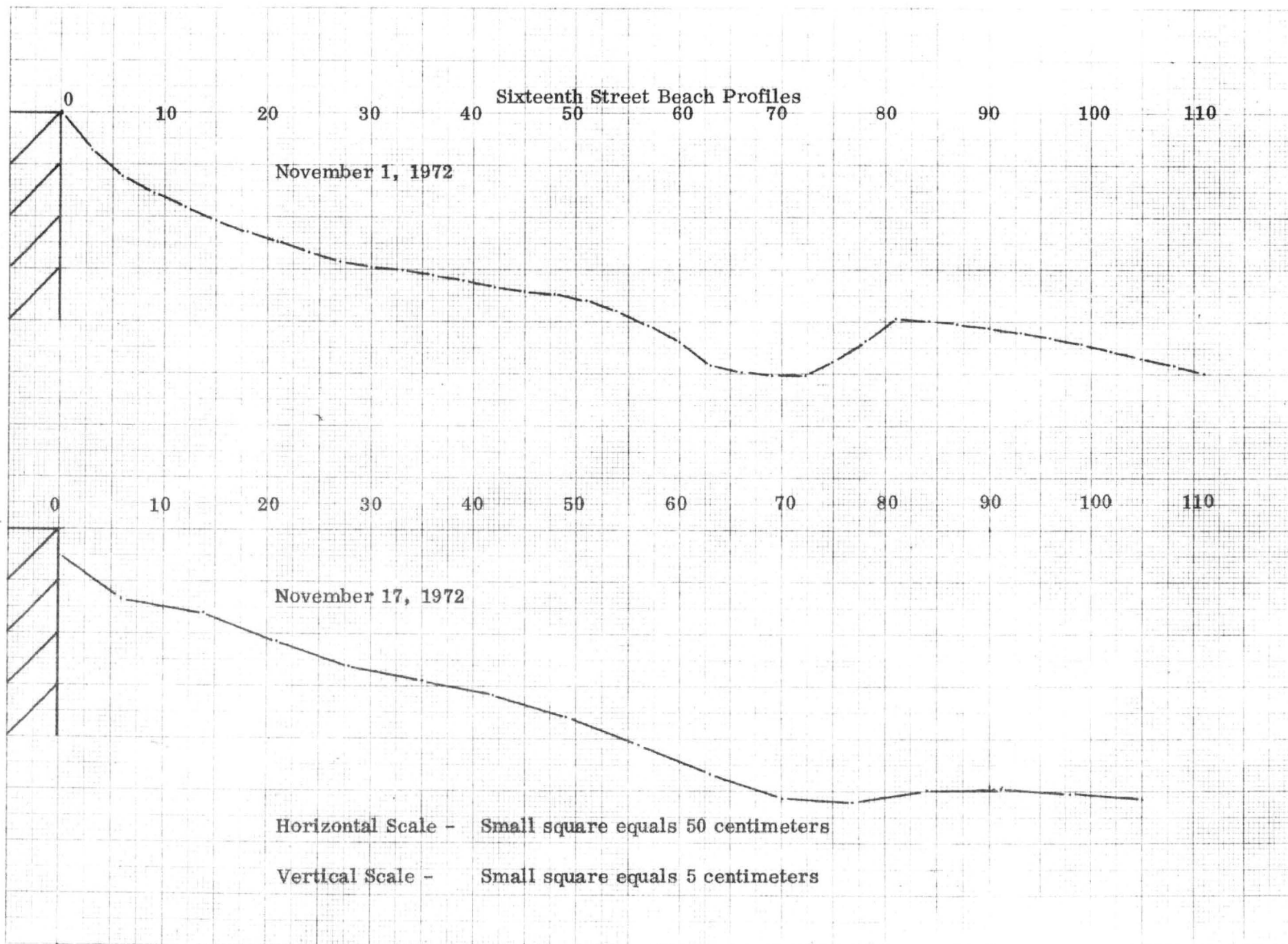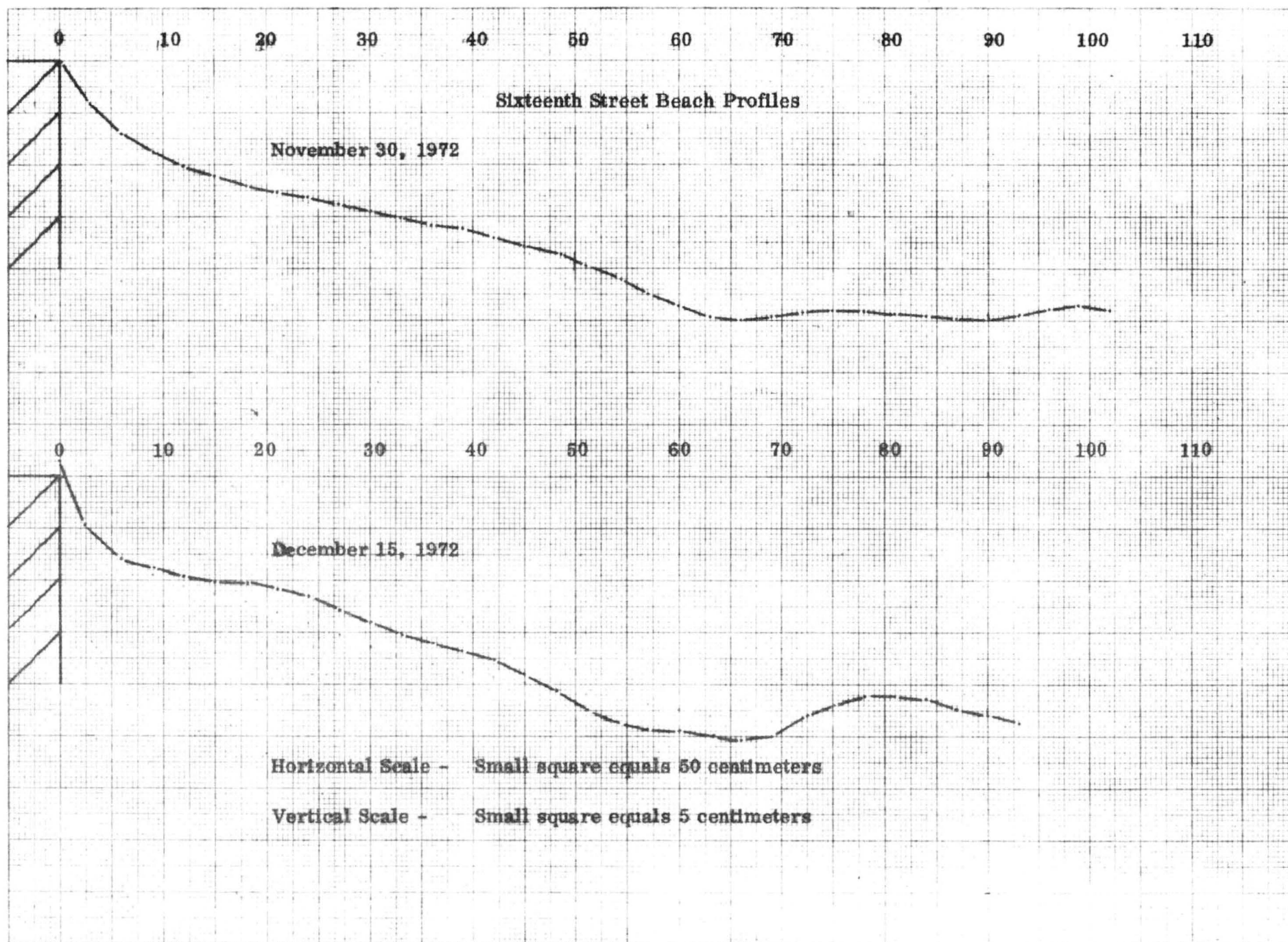
March 2, 1973

Sixteenth Street Beach Profiles

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Sixteenth Street Beach Profiles

March 16, 1973

March 30, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

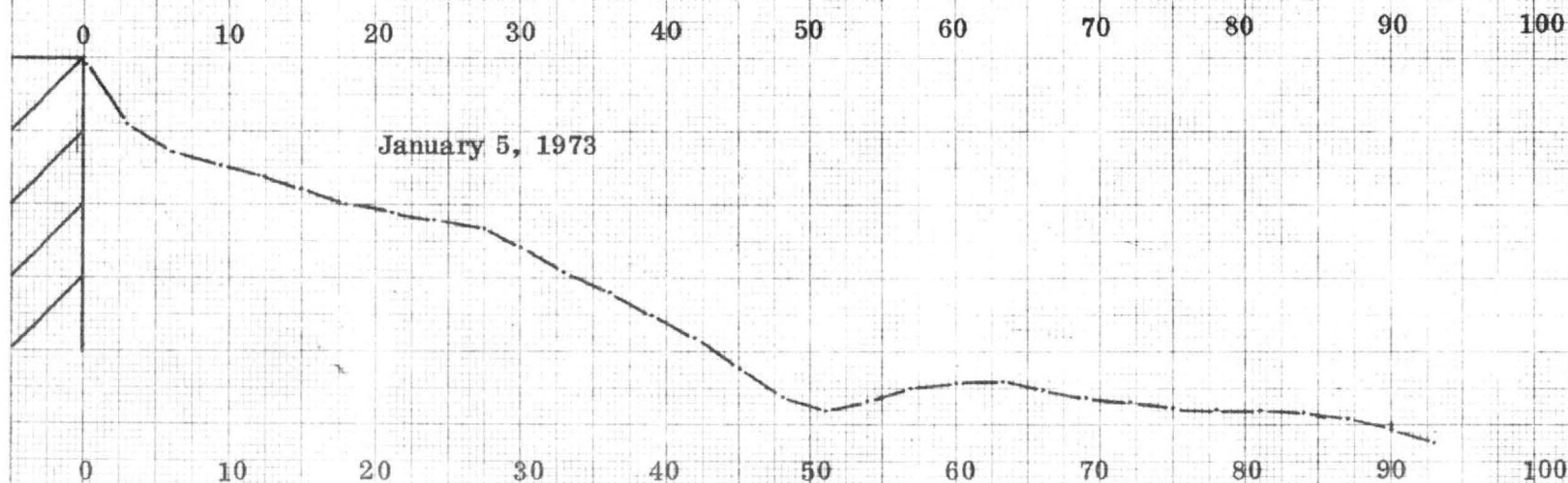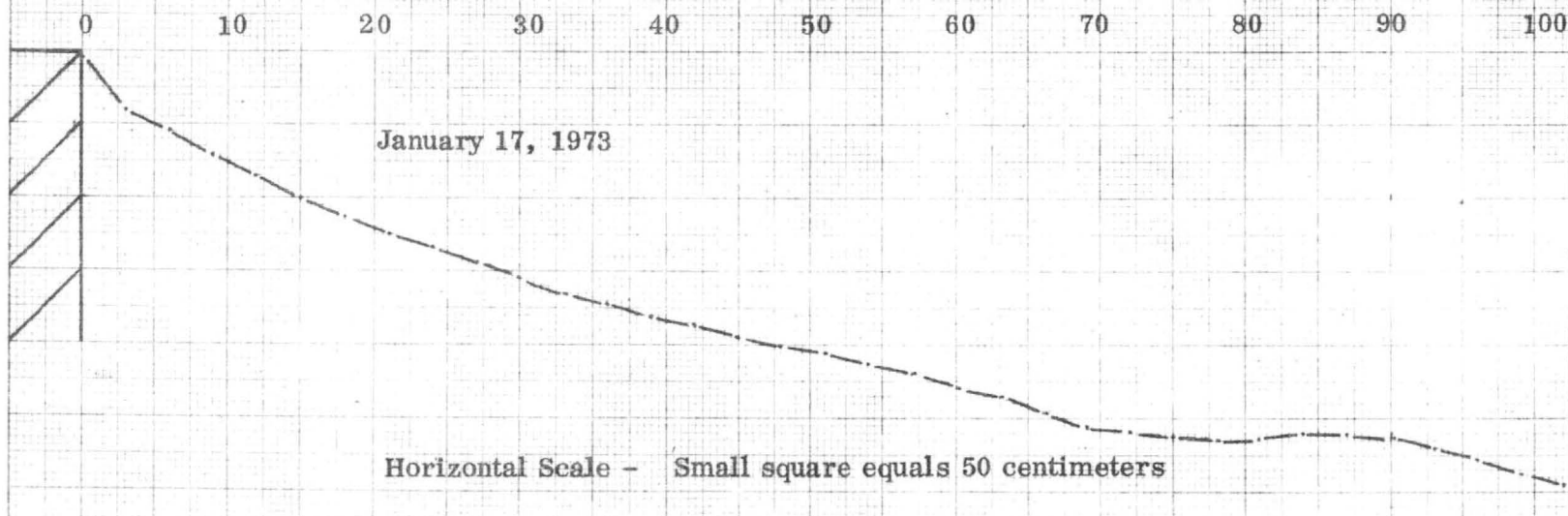Sixteenth Street Beach Profile

April 16, 1973

April 27, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters
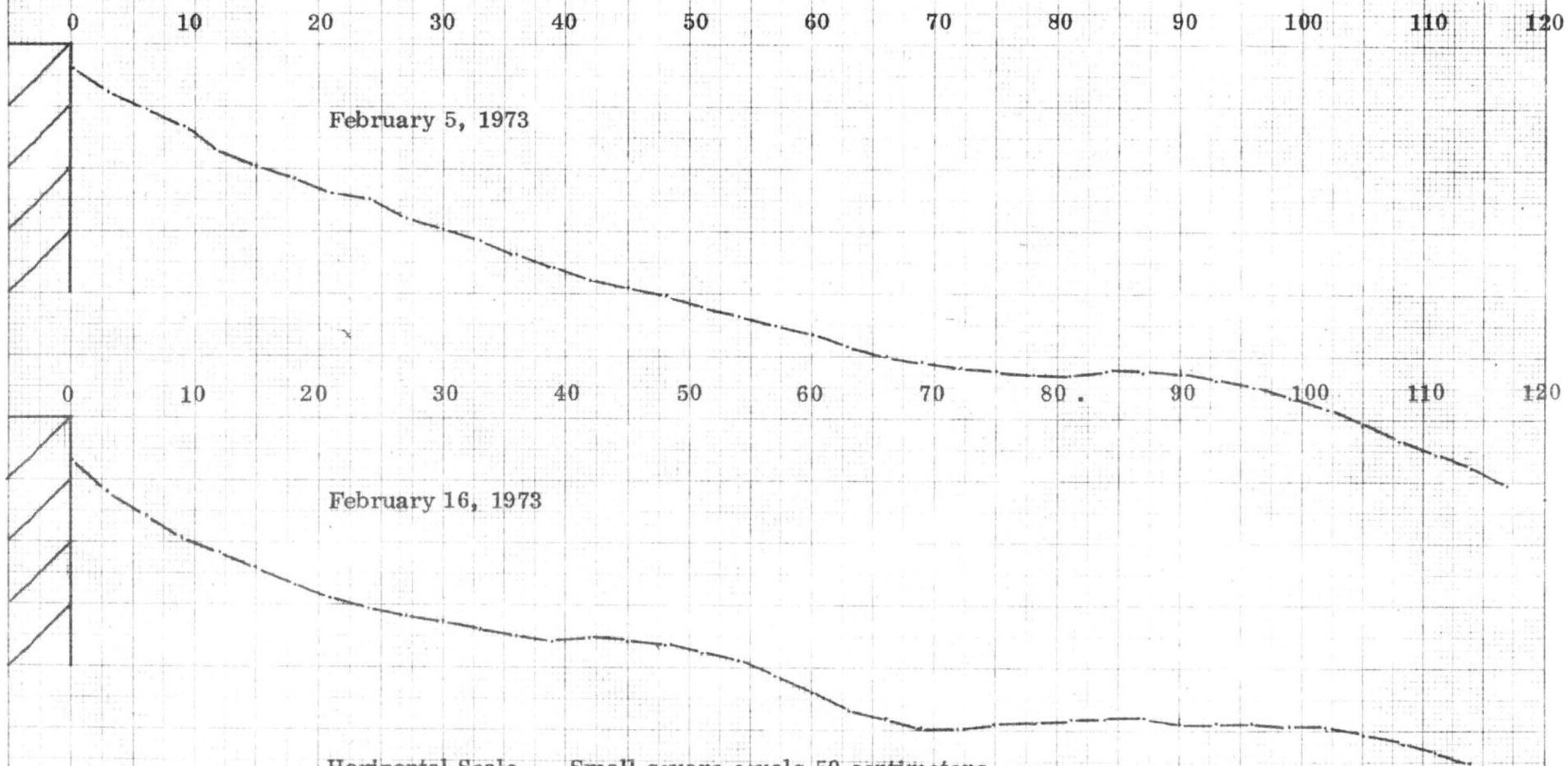
Sixteenth Street Beach Profile

May 12, 1973

May 28, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale –   Small square equals 5 centimeters

Sixteenth Street Beach Profile

June 8, 1973

June 25, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale –    Small square equals 5 centimeters

Sixteenth Street Beach Profiles

July 6, 1973

July 20, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Sixteenth Street Beach Profile

August 3, 1973

August 20, 1973

Horizontal Scale – Small square equals 50 centimeters
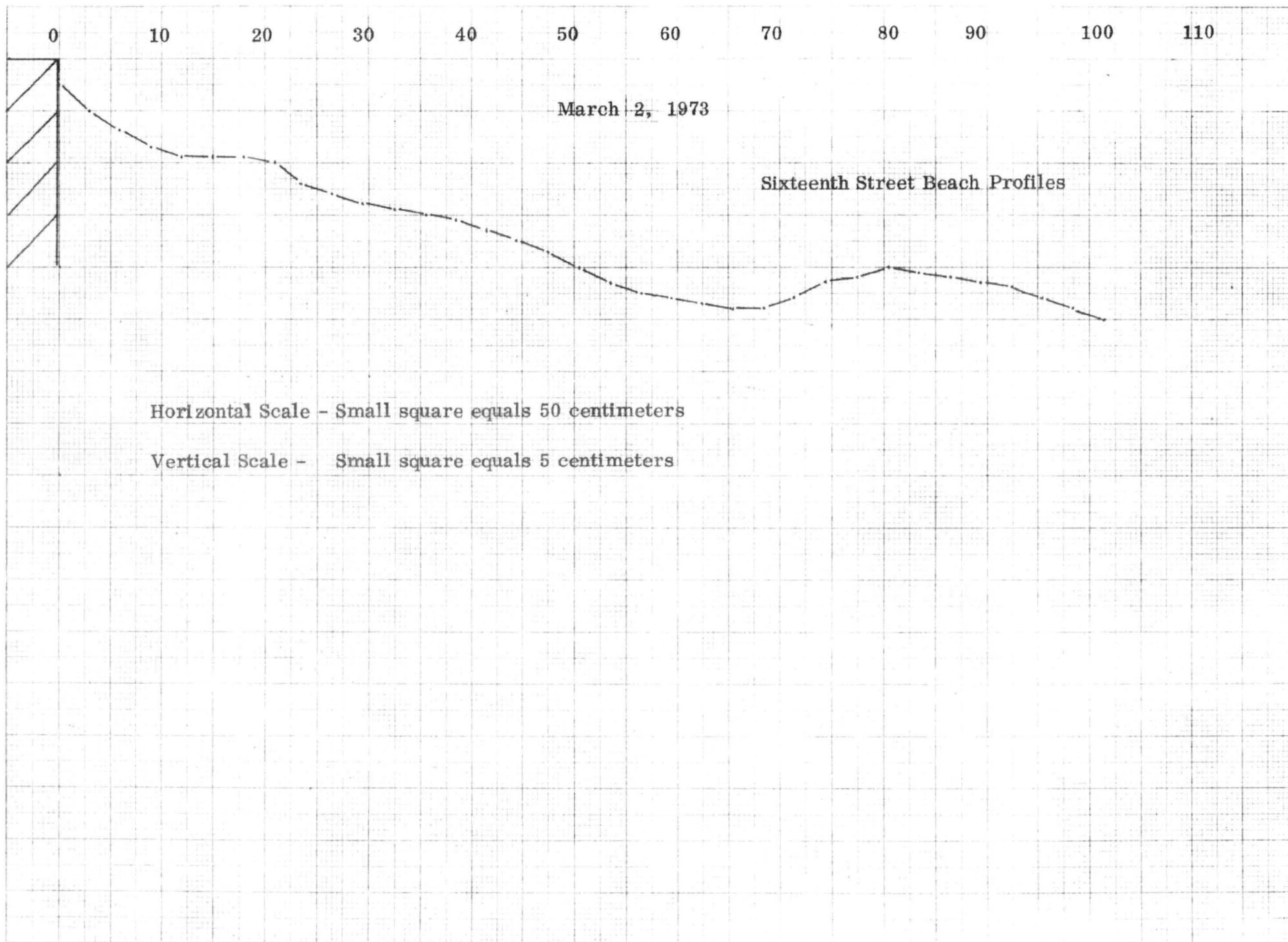
Vertical Scale –    Small square equals 5 centimeters

Sixteenth Street Beach Profile

September 6, 1973

September 25, 1973
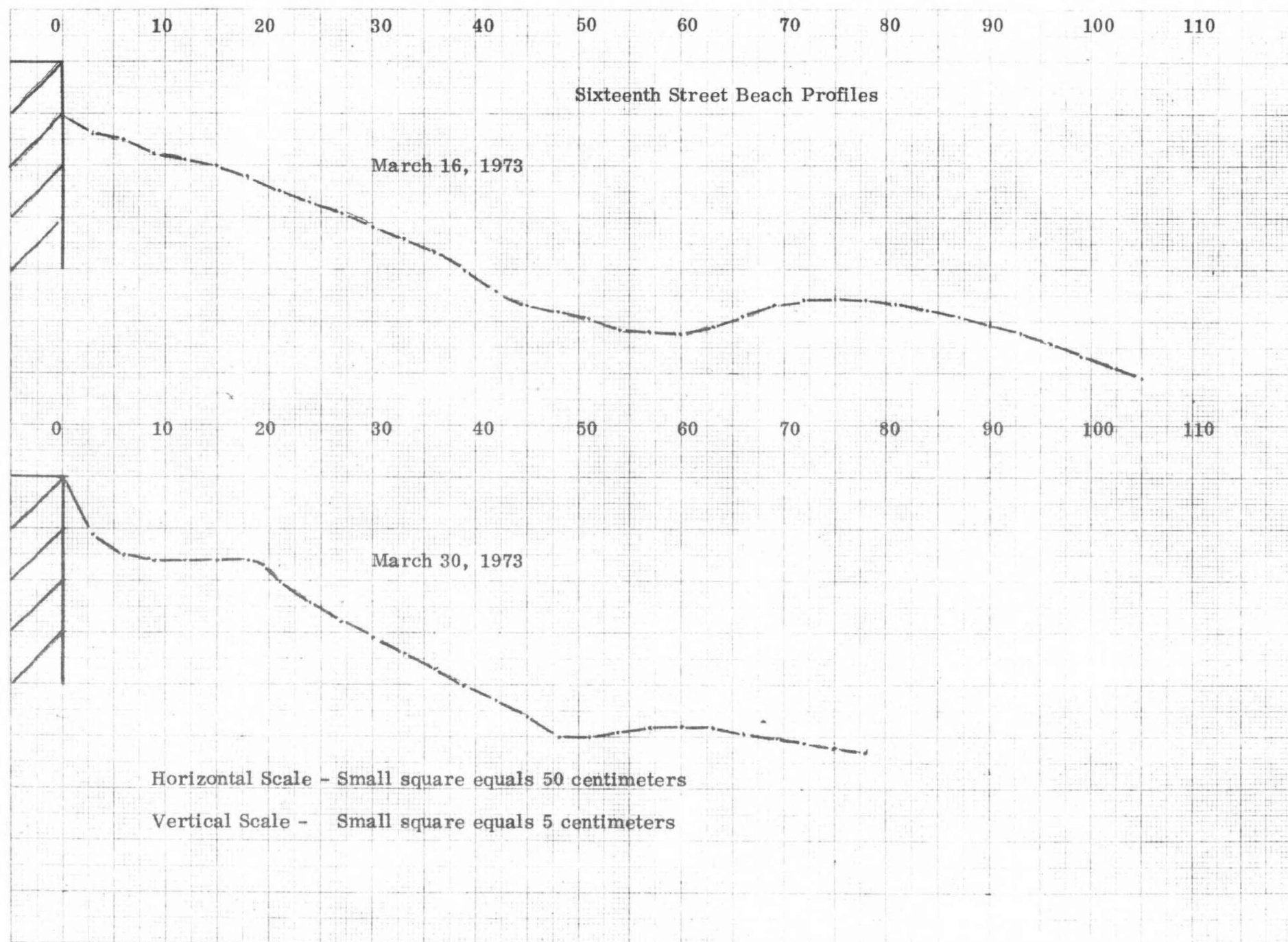
Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters

Sixteenth Street Beach Profile

October 8, 1973

October 22, 1973

Horizontal Scale – Small square equals 50 centimeters

Vertical Scale – Small square equals 5 centimeters