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AERIAL PHOTOGRAPHIC STUDY OF SHORELINE EROSION AND DEPOSITION, PAMLICO SOUND, NORTH CAROLINA

by
G. L. Stirewalt and Roy L. Ingram

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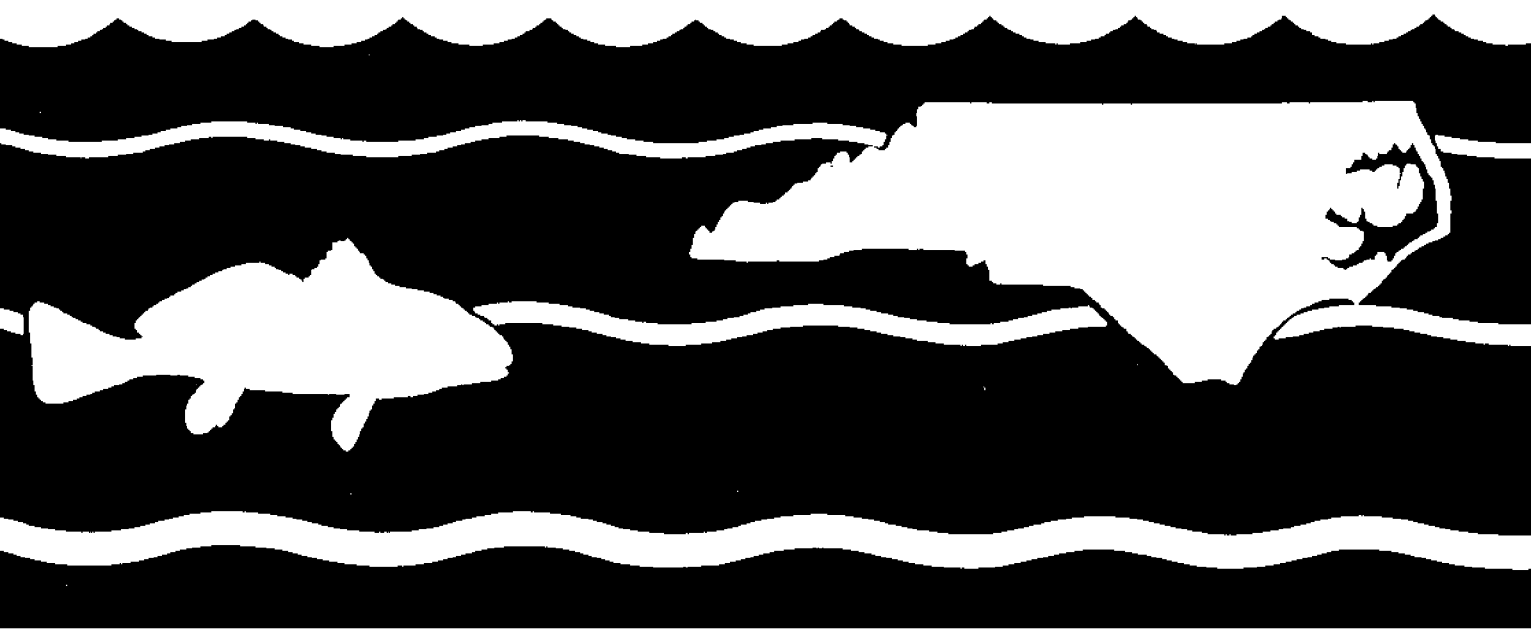

AERIAL PHOTOGRAPHIC STUDY

OF SHORELINE EROSION AND DEPOSITION,

PAMLICO SOUND, NORTH CAROLINA

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ABSTRACT

Recent changes in the shoreline morphology of Pamlico Sound, North Carolina, were determined by examining aerial photographs of varying dates between 1938 and 1971 at 16 sites. At all of the sites except one, shoreline retreat was dominant over shoreline advance. Only at Salvo, on both the ocean and sound side of the barrier island, was shoreline accretion dominant over shoreline retreat.

Along the mainland side of the sound the portion of the shoreline showing net erosion averaged approximately 15%; the remaining showed net deposition. Erosion rates varied up to 5 feet per year along semi-protected areas and up to 10 feet per year along exposed headlands.

Along the barrier island side of the sound approximately 75% of the shorelines were retreating at maximum rates of about 8 feet per year. The remaining 25% of the shorelines were accreting sediments.

Along the ocean side of the barrier island about 95% of the shorelines were retreating at rates up to approximately 15 feet per year. Only about 5% of the shorelines were advancing.

INTRODUCTION

Pamlico Sound of North Carolina is the largest body of water inside a barrier island system along the entire coast of the United States. Sixteen study localities were selected to determine changes in shoreline morphology along both the mainland and barrier island sides of the sound (Fig. 1). Information in this report is based on studies of aerial photographs of two to seven dates between 1938 and 1971 for each locality. Table 1 lists the dates and sources of the aerial photographs for each of the sixteen localities.

Several workers previously have discussed the limitations of using aerial photography to analyze shoreline changes (El-Ashry and Wanless, 1968; Langfelder, Stafford, and Amein, 1968). Photographs record instantaneous shoreline positions. Comparison of any two photographs reveals the net change between those two dates, and that new change may vary widely from the mean conditions affecting the area over a long term period. Also, as pointed out by those workers, the volume of material involved in the zone of change cannot be determined from aerial photographs alone. Aerial photographs of the Pamlico Sound area make it possible to document net changes over a 30-year period for some of the study localities. This period is long enough to permit the determination of long-term trends in shoreline alteration. Also short-term effects can be better documented with aerial photography than with any other method.

Table 1: Dates and Sources of Aerial Photographs
For Each Study Locality

DATE	LOCALITY NUMBER															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1938				USDA	USDA	USDA	USDA	USDA	USDA							
1939			USDA					USDA	USDA							
1945				CGS						CGS	CGS		CGS			
1948																
1951																
1953					CGS	CGS					CGS		CGS	CGS		
1954																
1955											CGS		CGS	CGS		
1958																
1959												CGS				
1961																
1962	CGS	CGS	CGS	CGS	CGS	CGS		CGS	CGS		CGS		CGS	CGS	CGS	CGS
1962S											CGS		CGS	CGS		
1965																
1967																
1968																
1971	UNC	UNC	UNC	UNC	UNC	UNC	UNC	UNC	UNC	UNC	UNC	UNC	UNC	UNC	UNC	UNC

CGS = Coast and Geodetic Survey aerial photographs

USDA = United States Department of Agriculture aerial photographs

UNC = University of North Carolina aerial photographs (taken particularly for this project)

For most localities studied, the position of the land - water boundary on the photographs was used to determine areas of change along the shoreline. In a few areas, the high water line was used where it was obvious that consecutive photographs were taken at different tidal levels and the photographs could be accurately compared only by using the high water line on each. The positions of both the land- water boundary and the high water lines are influenced by variable wave run-up on a sloping beach. No correction factor was applied to account for tidal changes on the land - water boundary since, as shown by Langfelder, Stafford, and Amein (1968), the use of any constant correction factor for tidal variations along a shoreline with varying beach slopes introduces further inaccuracies. Changes in shoreline morphology are more striking than tidal variations, and the land - water boundary reflects erosion and accretion equally well.

Although other workers have utilized aerial photography to survey shoreline changes along the North Carolina coast (Dolan and Vincent, 1972; El-Ashry and Wanless, 1968; Langfelder, Stafford, and Amein, 1968; Athearn and Ronne, 1963) they have concentrated mainly upon the ocean side of the barrier island system. The present study examines shoreline changes along the mainland salt marsh environment which has not been analyzed previously, and it contrasts changes in the shoreline of that environment with changes in both the lagoonal

and ocean sides of the barrier island system. The documentation of new information on the effects of man-made features (as well as natural forces) upon the total lagoonal shoreline is also pertinent since parts of the study area will likely experience increased development by man in the near future.

DATA PRESENTATION AND DISCUSSION

A. Mainland Side of Pamlico Sound

Study localities 1 through 5 are situated along the mainland side of Pamlico Sound as shown in Figure 1.

Figure 2 illustrates the 1962 and 1971 shorelines at Locality 1 (Long Wretch Creek). Strong net erosion of the eastwardly-directed point is apparent between these dates. Approximately 65 percent of the shoreline experienced net erosion and about 35 percent net deposition for the time period analyzed. Estimates indicate that at least 6.5×10^5 square feet of salt marsh have been lost to erosion in the vicinity of the point between 1962 and 1971. Erosion rates vary from greater than 10 feet per year at the point to negative rates with localized deposition both north and south from the point. This high erosion rate has resulted from wave and/or current action within the sound. Some localized net deposition has occured in the sheltered stream channel on the point.

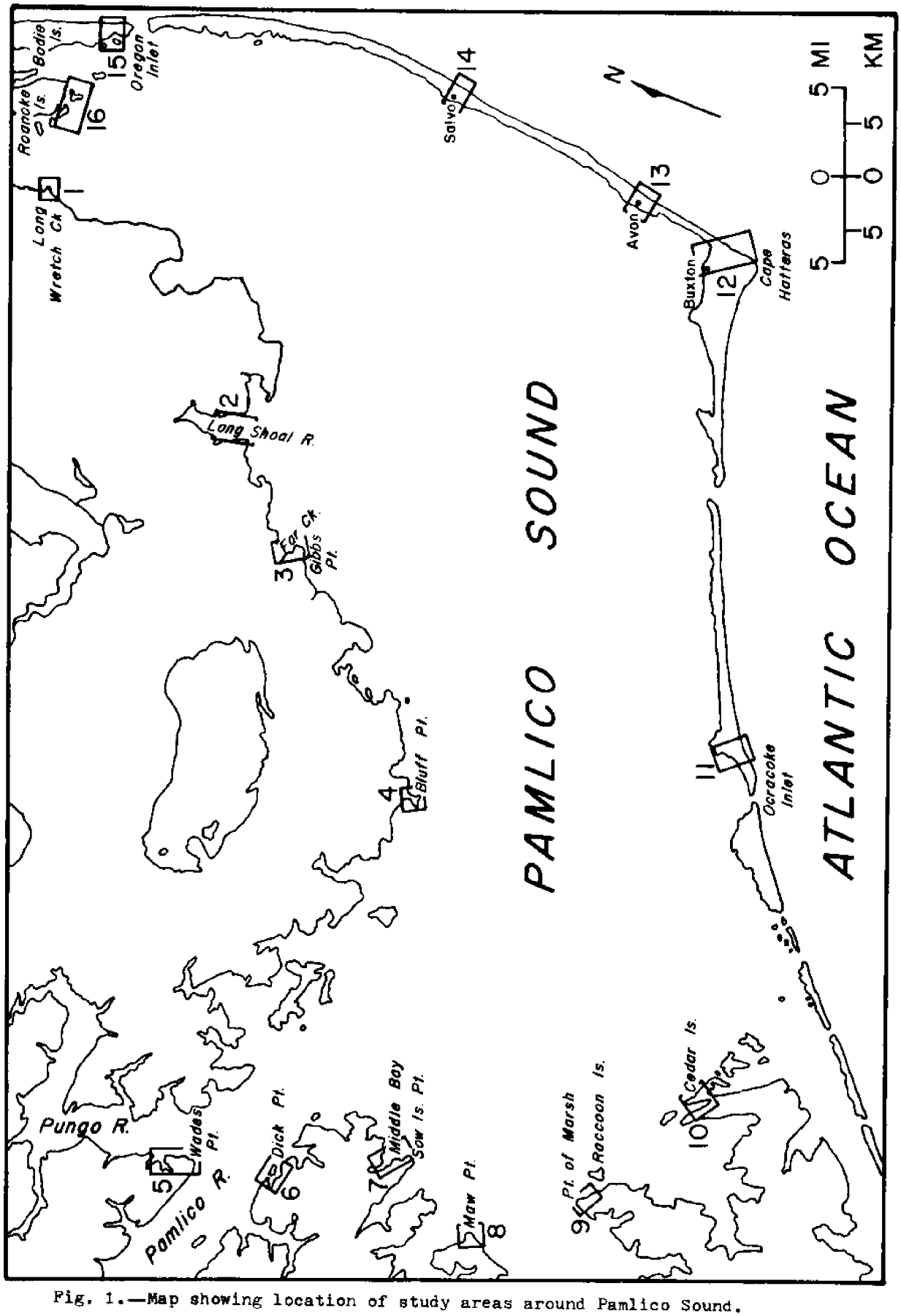


Fig. 1.—Map showing location of study areas around Pamlico Sound.

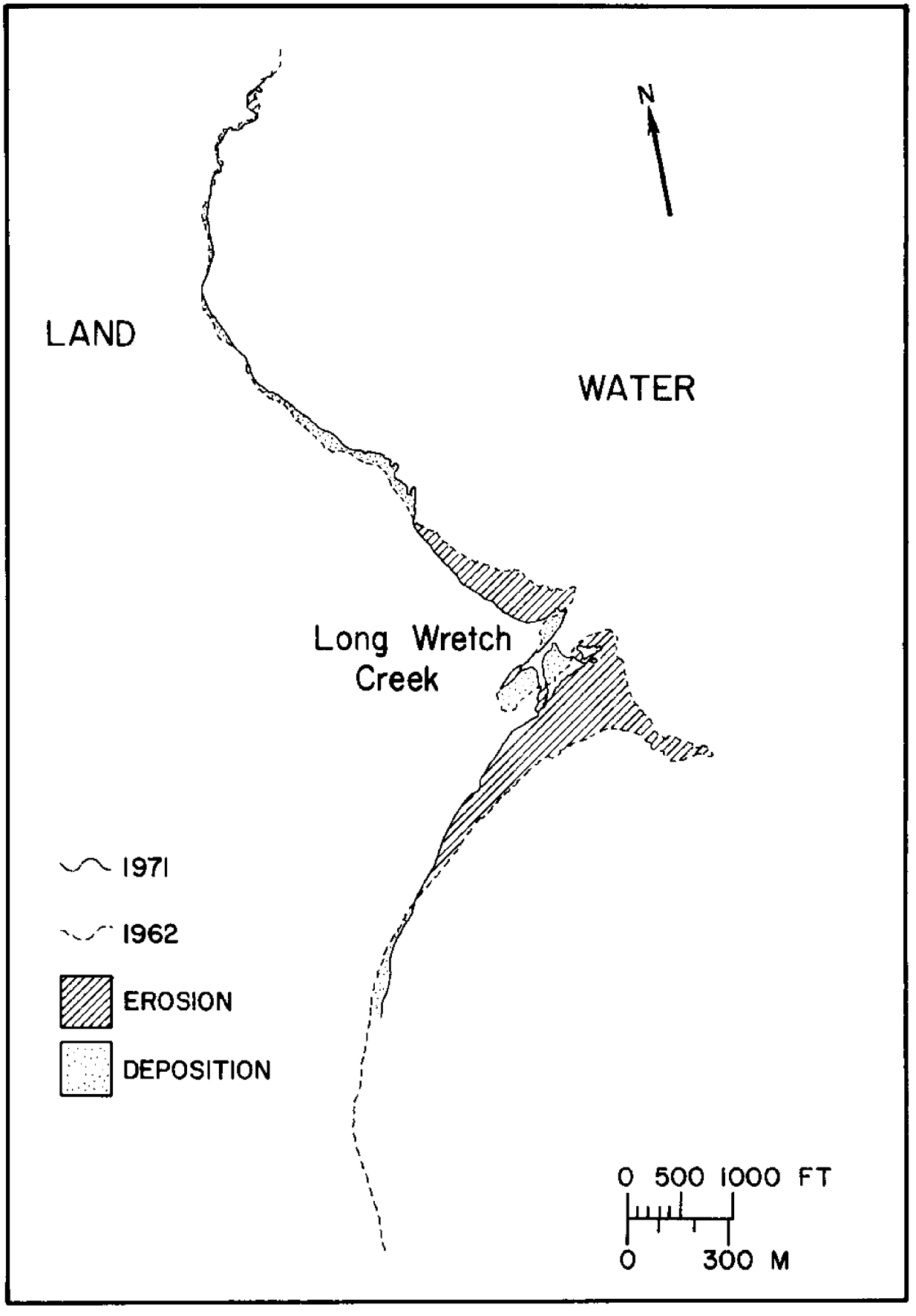


Fig. 2.—Shoreline changes at Locality 1 (Long Wretch Creek), 1962 to 1971.

Locality 2 along Long Shoal River indicates that erosion rates up to 5 feet per year occur along this semi-protected part of the marshy mainland (Fig. 3). Nearly 75 percent of the shoreline area shows net erosion, and no greater than 25 percent illustrates net deposition over the period from 1962 to 1971.

Locality 3 near Engelhard and Gibbs Point illustrates net erosion over fully 85 percent of the shoreline between 1939 and 1971 (Fig. 4). The remaining 15 percent of the shoreline indicated little change except for minor net deposition. From a comparison of shorelines from aerial photographs dating 1939 and 1962 (Fig. 5) and 1962 and 1971 (Fig. 6), slightly more deposition is suggested over these shorter periods. This is particularly true of the 1962 - 1971 shoreline comparison (Fig. 6). which indicates deposition on approximately 25 percent of the shoreline. However, the bulk of the modification is erosional, for all pairs of photographs compared. Net erosion between 1939 and 1971 suggests a maximum rate of about 3.5 feet per year at the least protected parts of L3 (i.e. - Gibbs Point). This maximum rate doubtless results from wave and current activity in the sound. Rates of erosion less than 3.5 feet per year persist in the more sheltered parts of Far Creek.

Locality 4 illustrates major erosional effects on a prominent headland (Bluff Point) on the mainland side of Pamlico Sound. An

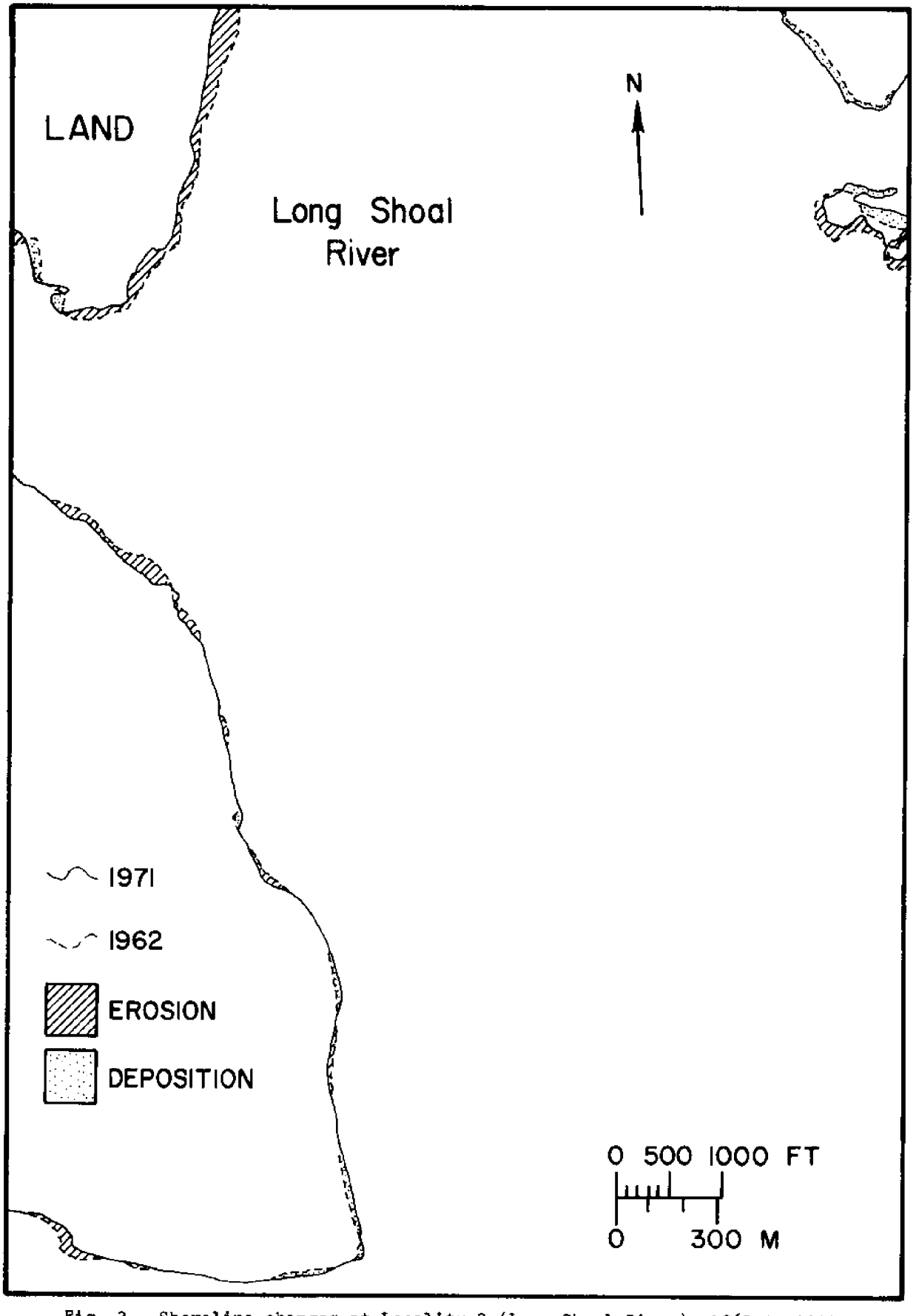


Fig. 3.—Shoreline changes at Locality 2 (Long Shoal River), 1962 to 1971.

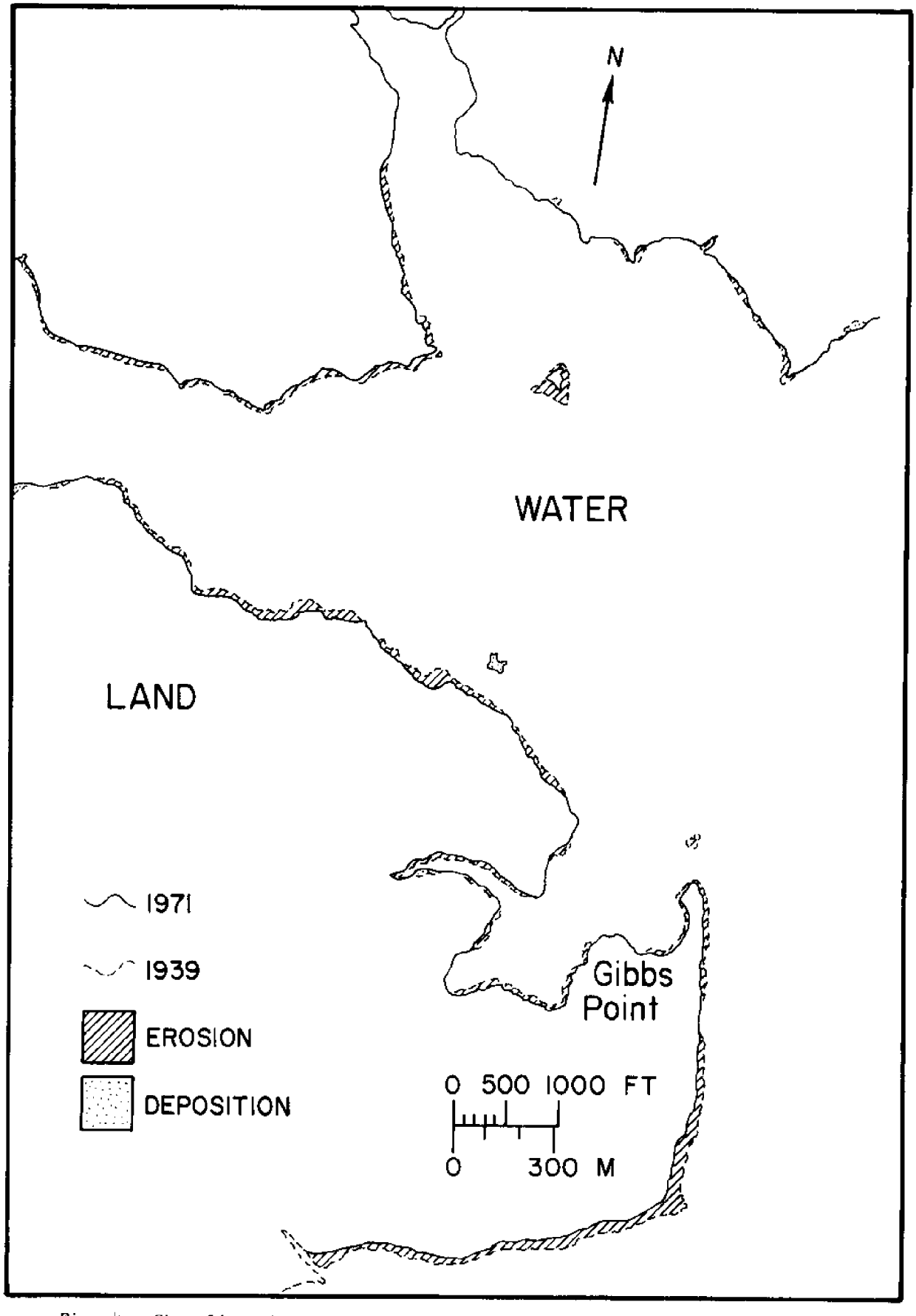


Fig. 4.—Shoreline changes at Locality 3 (Gibbs Point), 1939 to 1971.

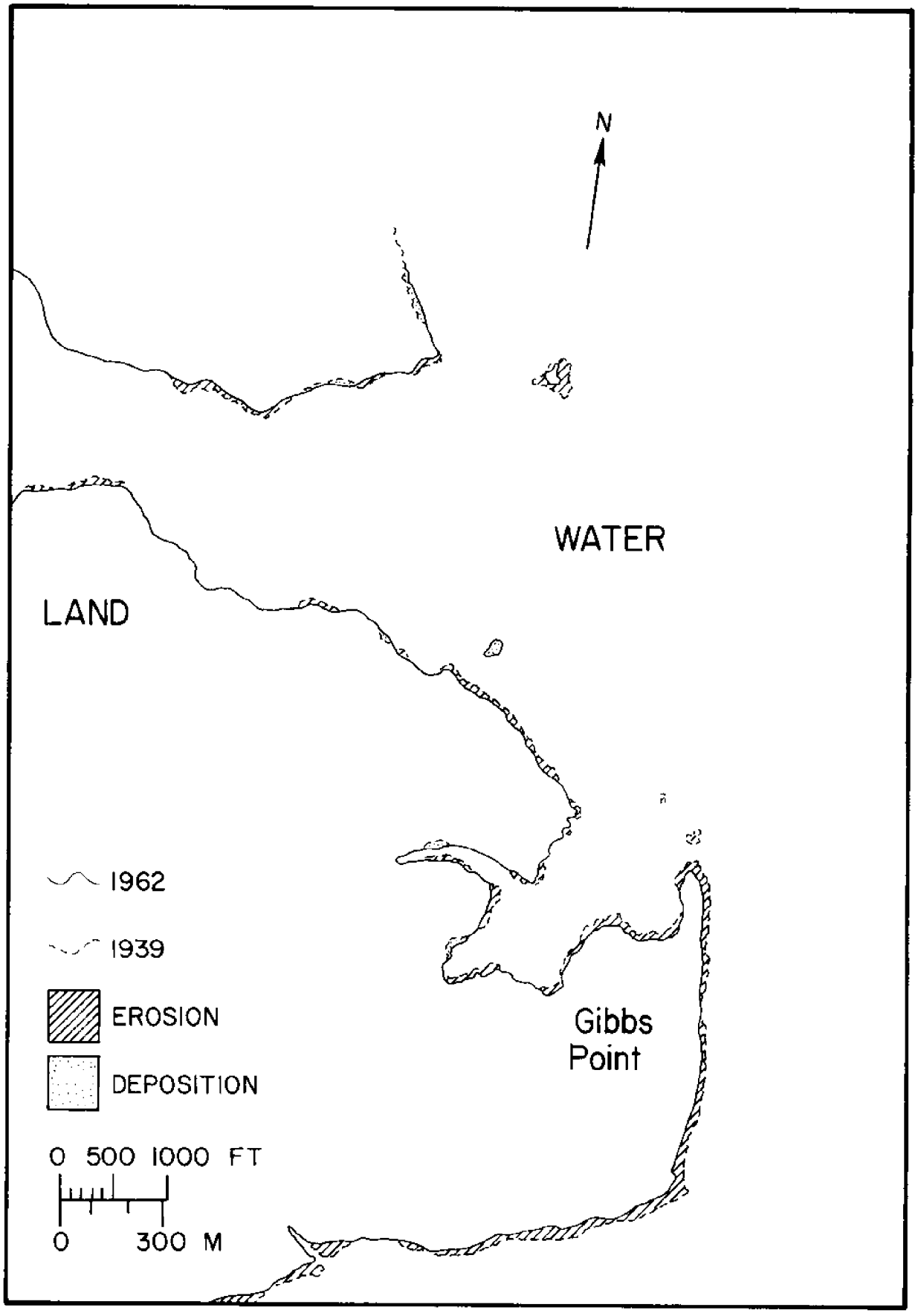


Fig. 5.—Shoreline changes at Locality 3 (Gibbs Point), 1939 to 1962.

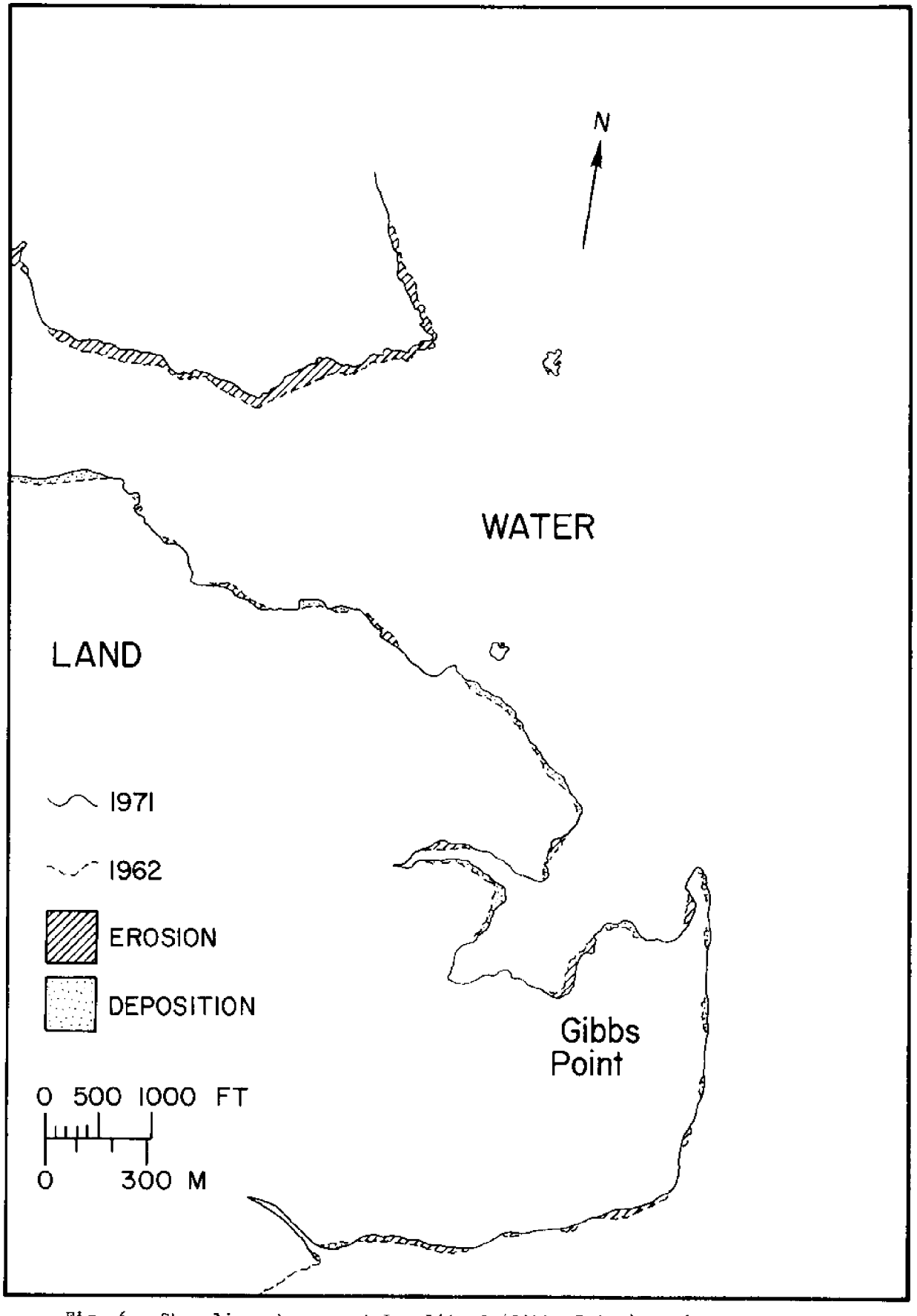


Fig. 6.—Shoreline changes at Locality 3 (Gibbs Point), 1962 to 1971.

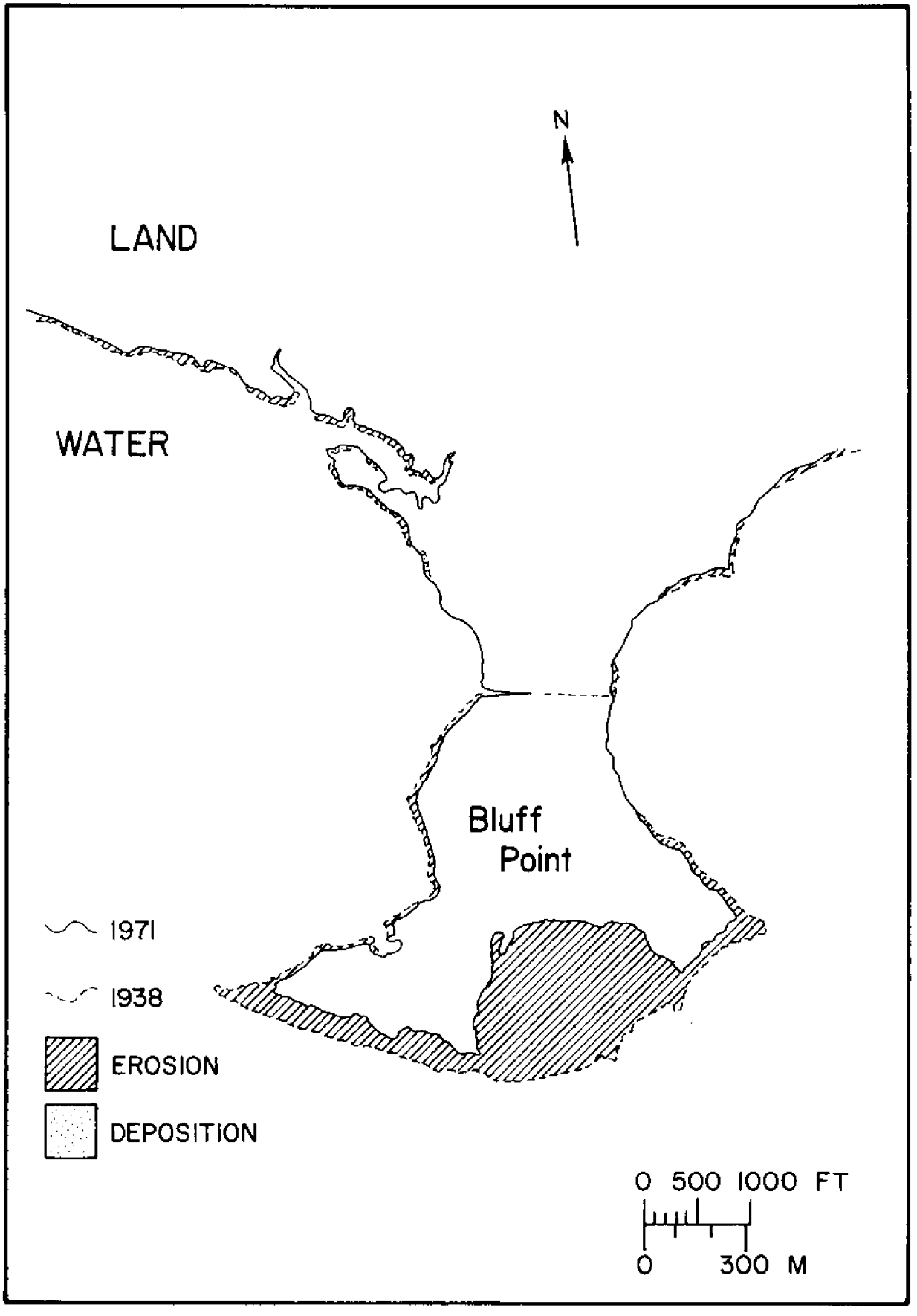


Fig. 7.—Shoreline changes at Locality 4 (Bluff Point), 1938 to 1971.

area approximately 1.9×10^6 square feet has eroded from Bluff Point between 1938 and 1971 (Fig. 7). A minimum erosion rate of 6 feet per year and a maximum rate of 45 feet per year are indicated along the south-facing headland. A comparison of shorelines from aerial photographs of 1938 and 1945 (Fig. 8) shows very little erosion during this period. Major erosion is indicated between 1945 and 1962 (Fig. 9) and 1962 - 1971 (Fig. 10). The accelerated erosion between 1945 and 1962 may have resulted largely from the 1958 hurricane from the south and/or the 1962 hurricane (Helene) from the northeast. Fully 90 to 95 percent of the headland shoreline has experienced erosion, a pattern reflected by all photographs analyzed. Only minor deposition (less than 5 percent) has occured on Bluff Point itself. However, the bay on the north-eastern side of Bluff Point does indicate some deposition, mainly between 1962 and 1971 (Fig. 10).

Locality 5 at Wades Point along the Pungo River illustrates net erosion between 1938 and 1971 along 90 to 95 percent of the shoreline (Fig. 11). Minor net deposition for this time period has occured over less than 5 percent of the shoreline. Erosion rates along the Pungo River up to 4.5 feet per year and up to 3 feet per year along the Pamlico River side of Wades Point are indicated by the shoreline changes shown in Figure 11. Shorelines from 1938 and 1953 (Fig. 12)

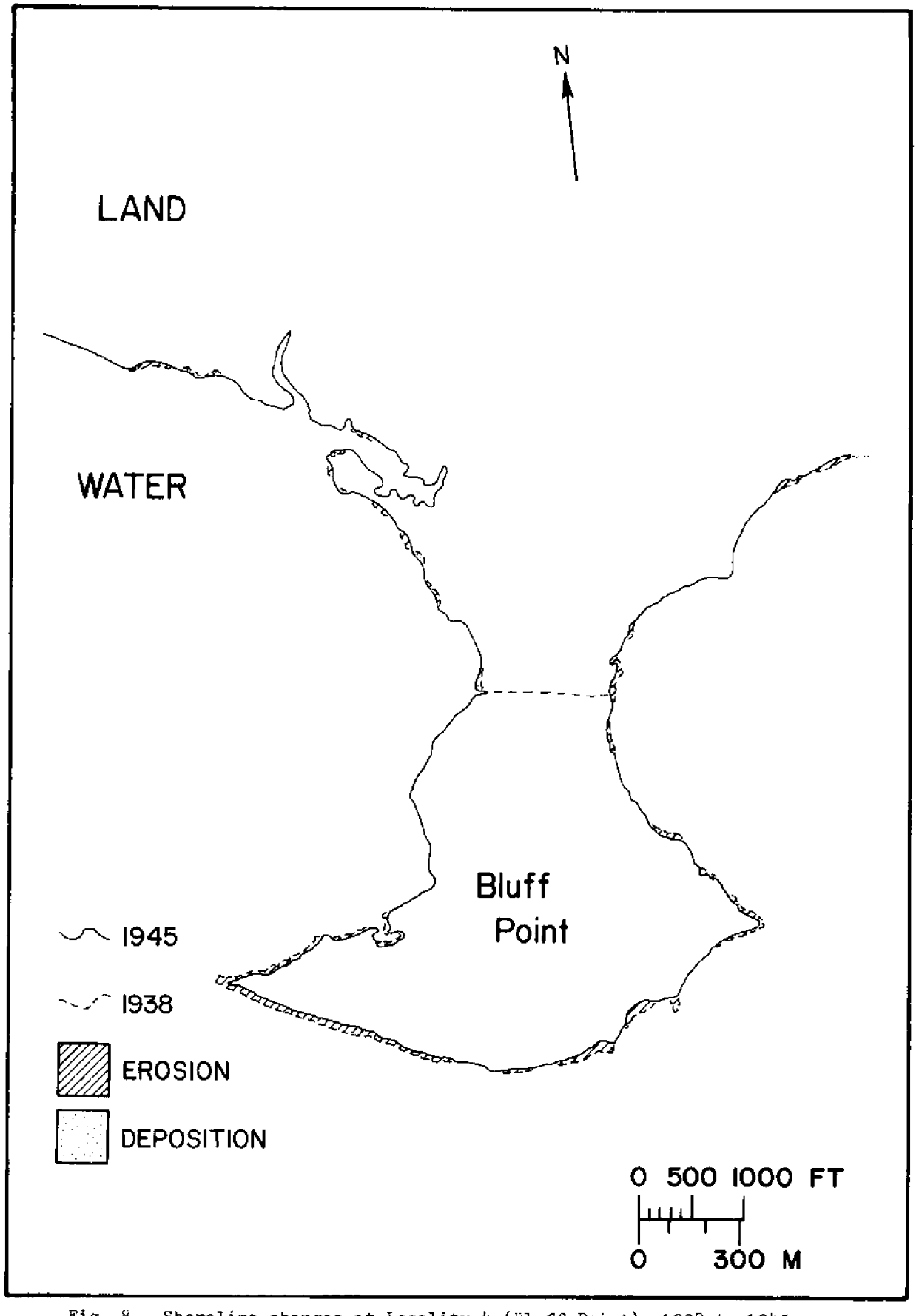


Fig. 8.—Shoreline changes at Locality 4 (Bluff Point), 1938 to 1945.

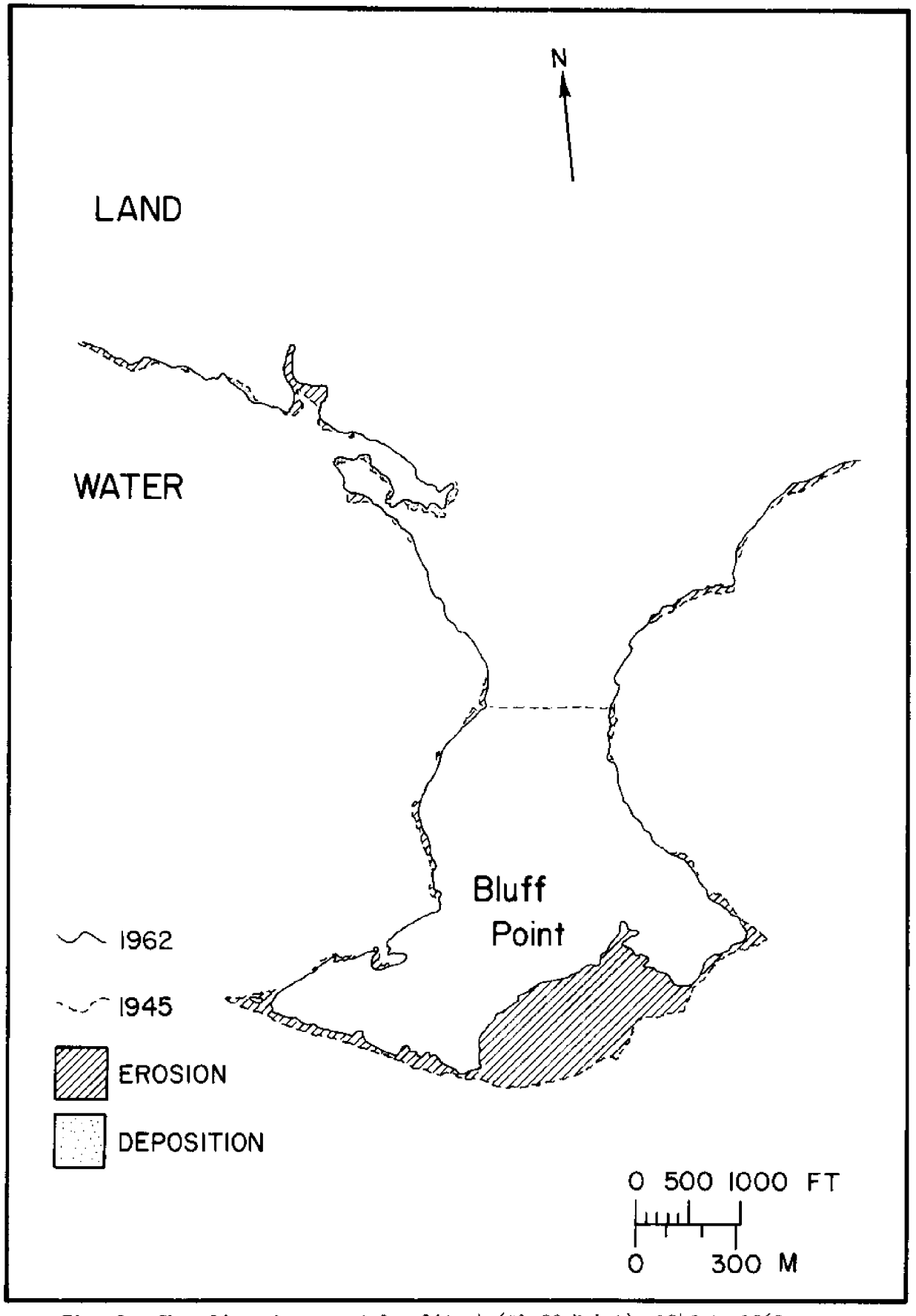


Fig. 9.—Shoreline changes at Locality 4 (Bluff Point), 1945 to 1962.

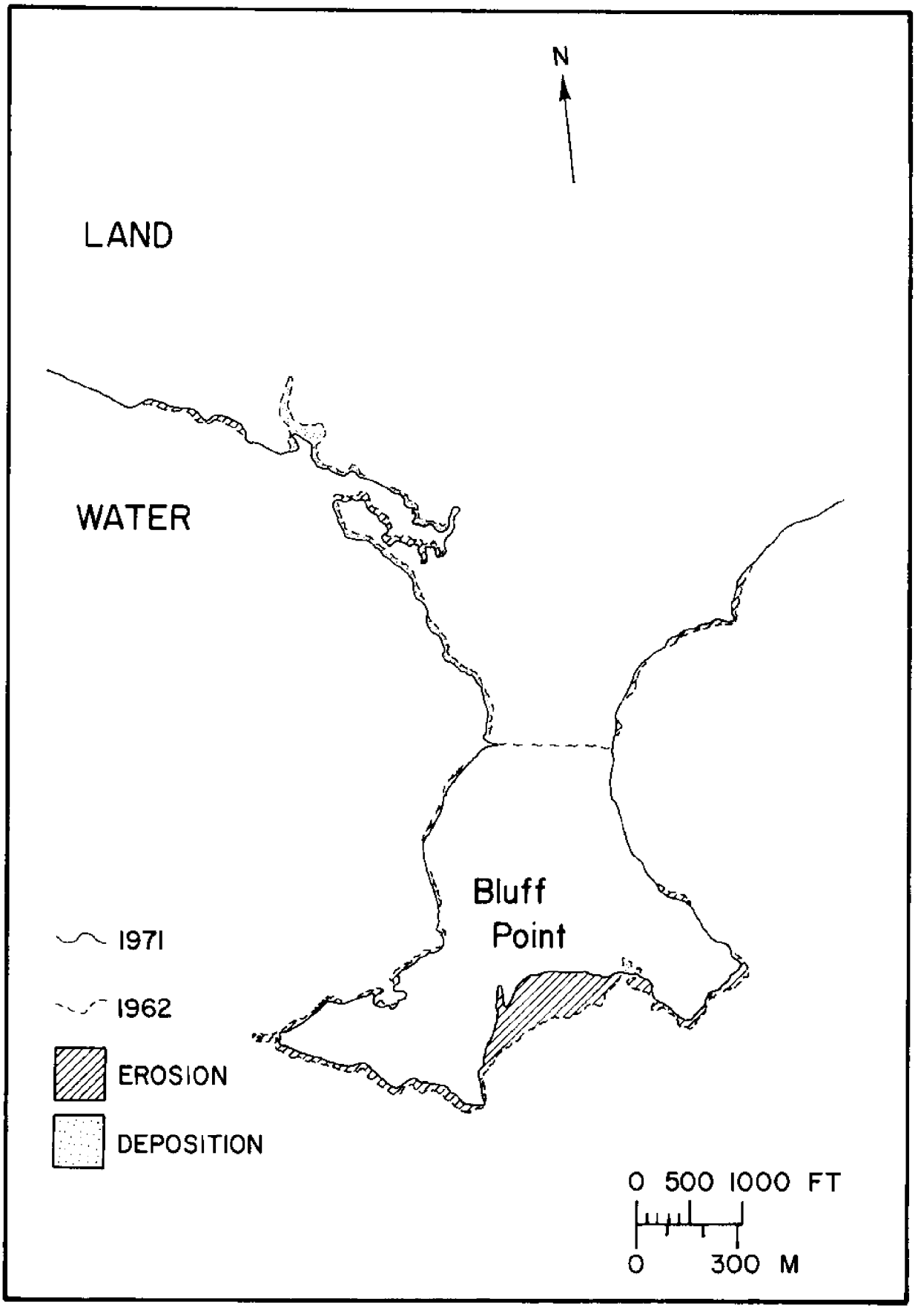


Fig. 10.—Shoreline changes at Locality 4 (Bluff Point), 1962 to 1971.

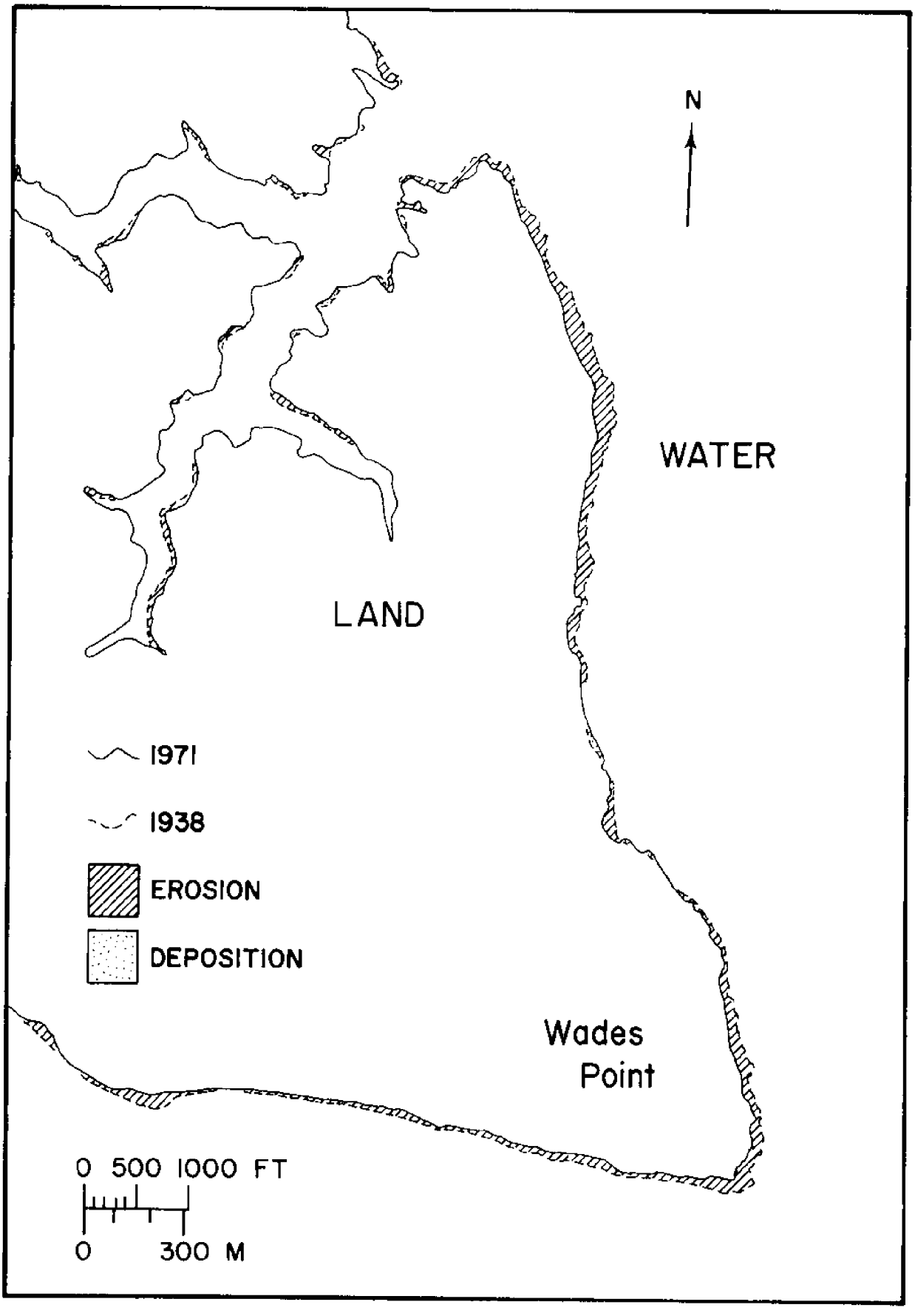


Fig. 11.—Shoreline changes at Locality 5 (Wades Point), 1938 to 1971.

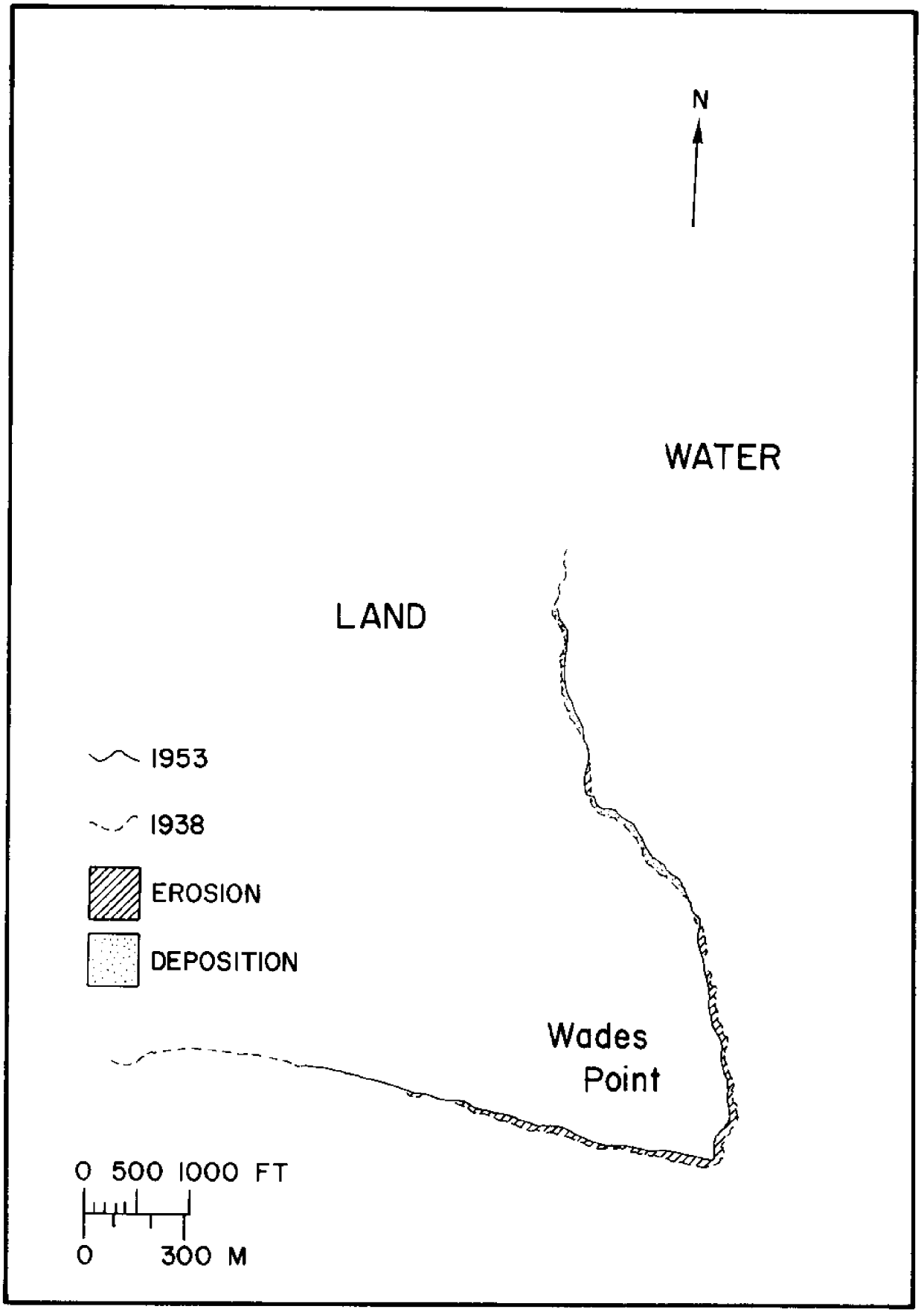


Fig. 12.—Shoreline changes at Locality 5 (Wades Point), 1938 to 1953.

show deposition over less than 20 percent of the shoreline area along the Pungo River. Figure 13 for 1953 and 1962 indicates less than 5 percent of the shoreline has experienced deposition, and this is less than 15 percent for 1962 and 1971 (Fig. 14). Therefore, changes in shoreline morphology at L5 appear to be most strongly related to erosional effects.

Localities 6 through 10 are located along the west-northwestern mainland side of Pamlico Sound with positions relative to major estuaries as shown in Figure 1. Locality 6 (near Dick Point) shows maximum erosion rates up to 4.5 feet per year along the Pamlico River, with rates less than 3 feet per year in the smaller sheltered estuary northwest of Dick Point (Fig. 15). A minimum of 95 percent of the shoreline along the Pamlico River at L6 shows net erosion, whether considering net changes between 1938 and 1971 (Fig. 15) or comparing shorlines from 1938 and 1962 (Fig. 16) or 1962 and 1971 (Fig. 17). Most net deposition between 1938 and 1971 has occured in the sheltered estuary northwest of Dick Point and is no greater than 5 percent of the net change shown (Fig. 15).

At Locality 7 near Sow Island Point and Middle Bay 85 to 90 percent of the shoreline experienced net erosion between 1938 and 1971 while less than 10 percent had net deposition (Fig. 18). Erosion rates up to 3 feet per year are indicated, although the island off

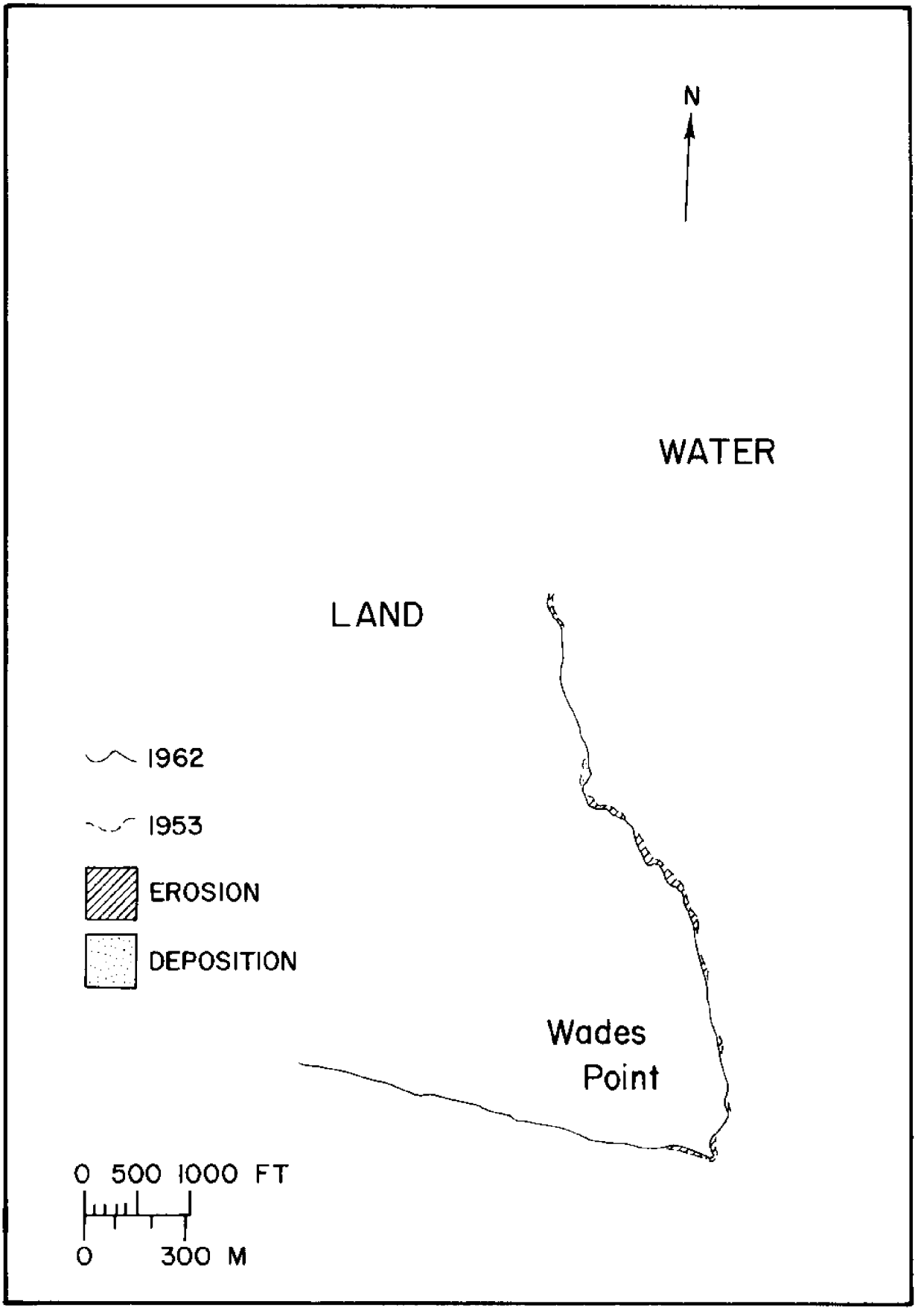


Fig. 13.—Shoreline changes at Locality 5 (Wades Point), 1953 to 1962.

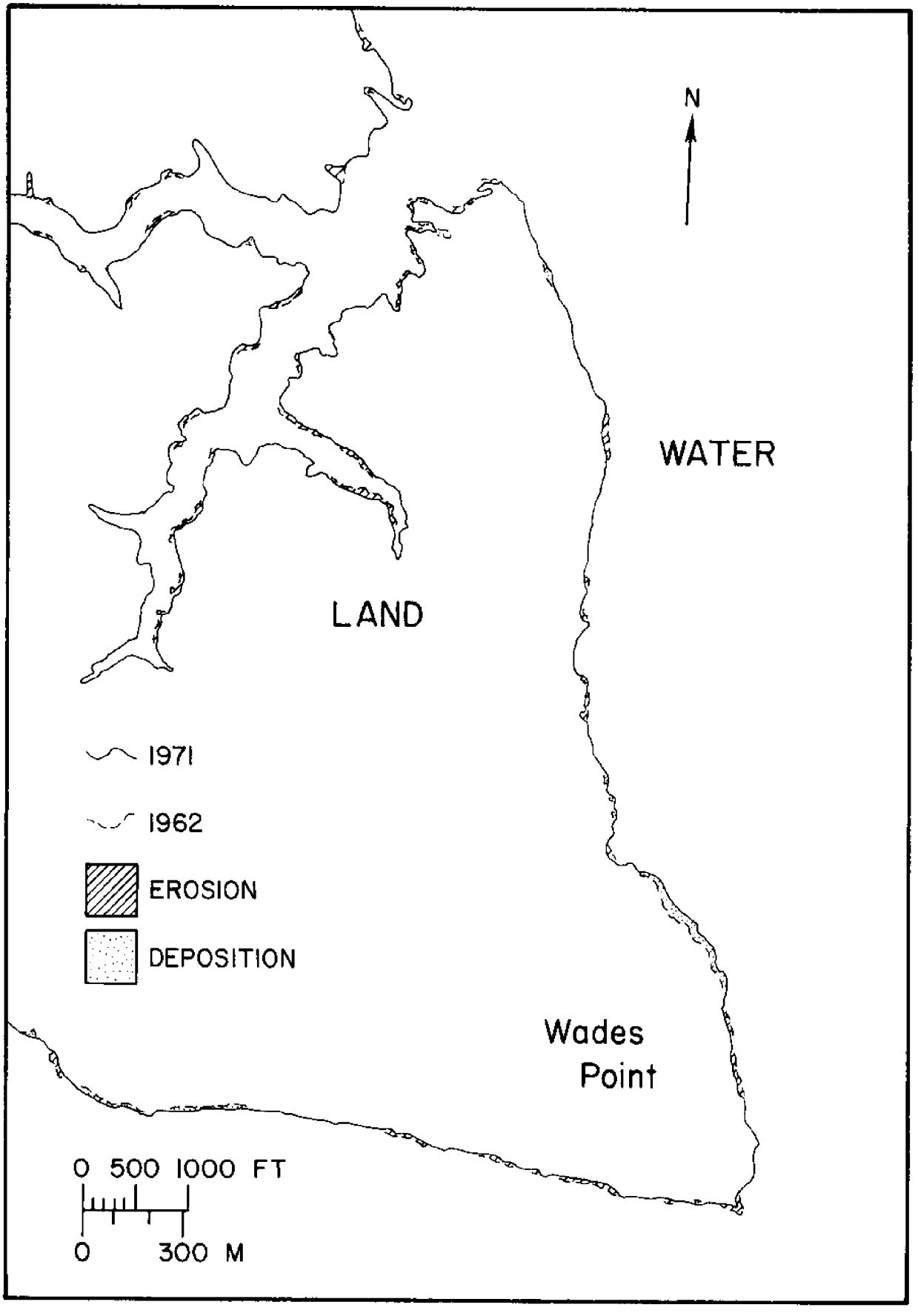


Fig. 14.—Shoreline changes at Locality 5 (Wades Point), 1962 to 1971.

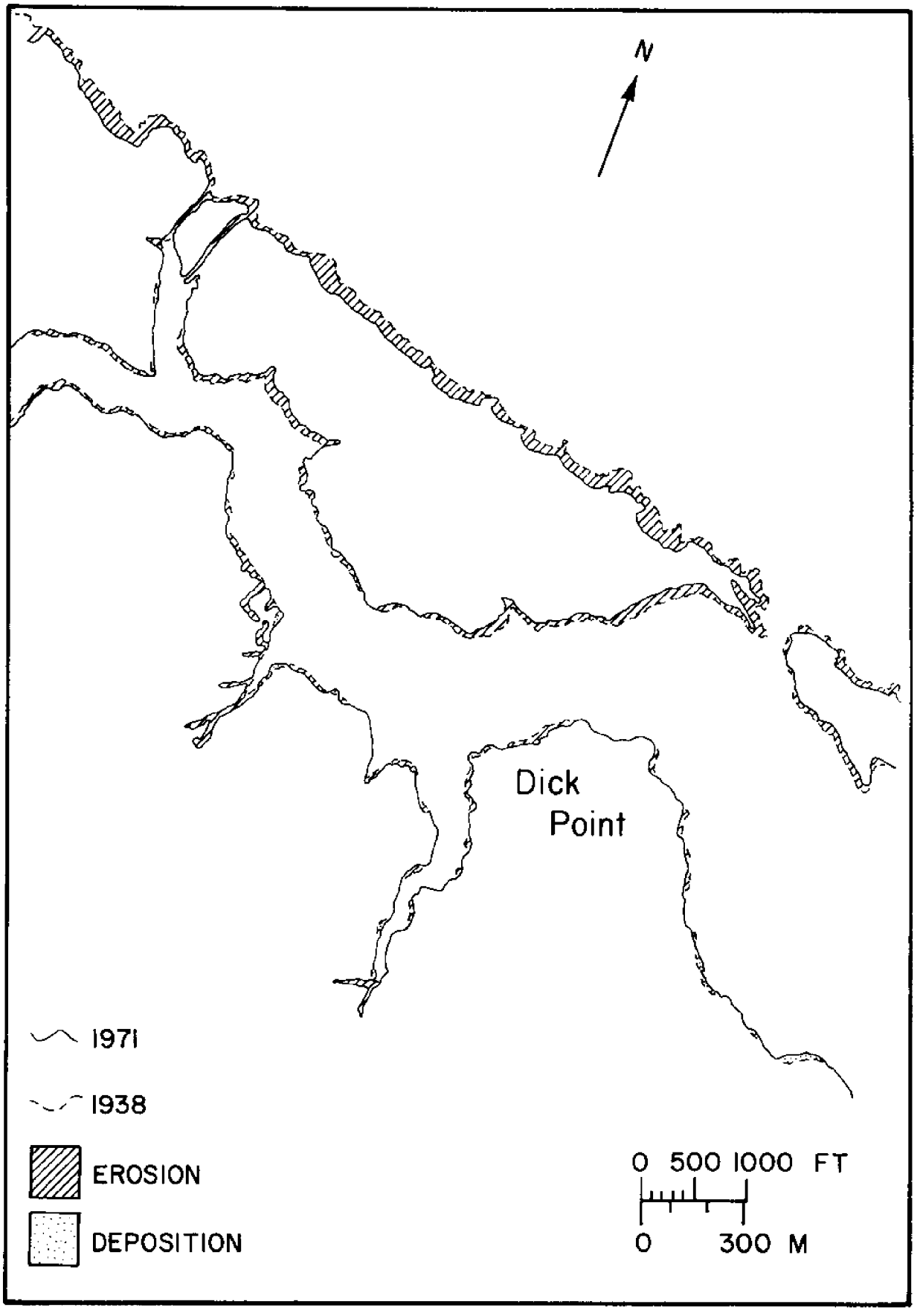


Fig. 15.—Shoreline changes at Locality 6 (Dick Point), 1938 to 1971.

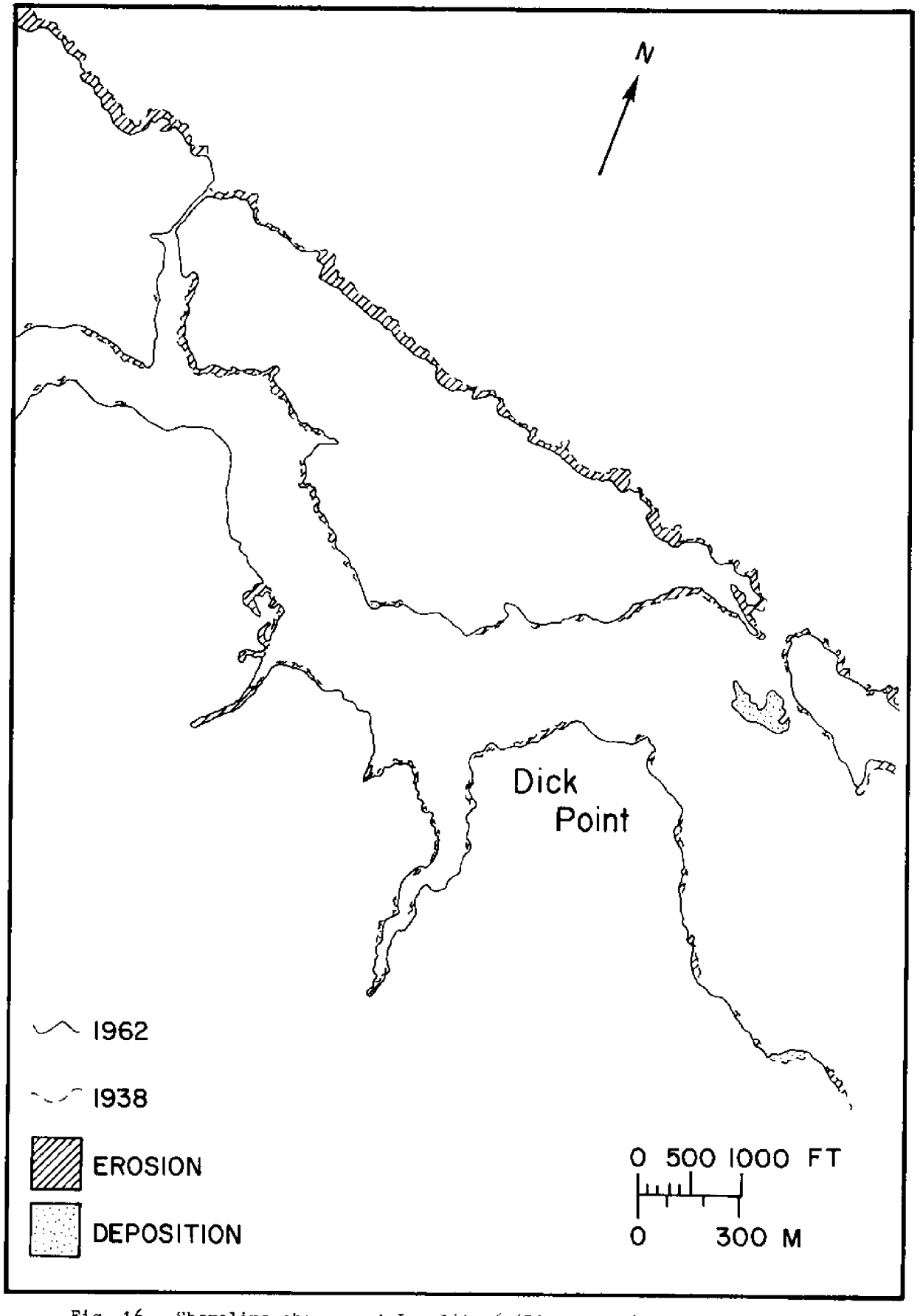


Fig. 16.—Shoreline changes at Locality 6 (Dick Point), 1938 to 1962.

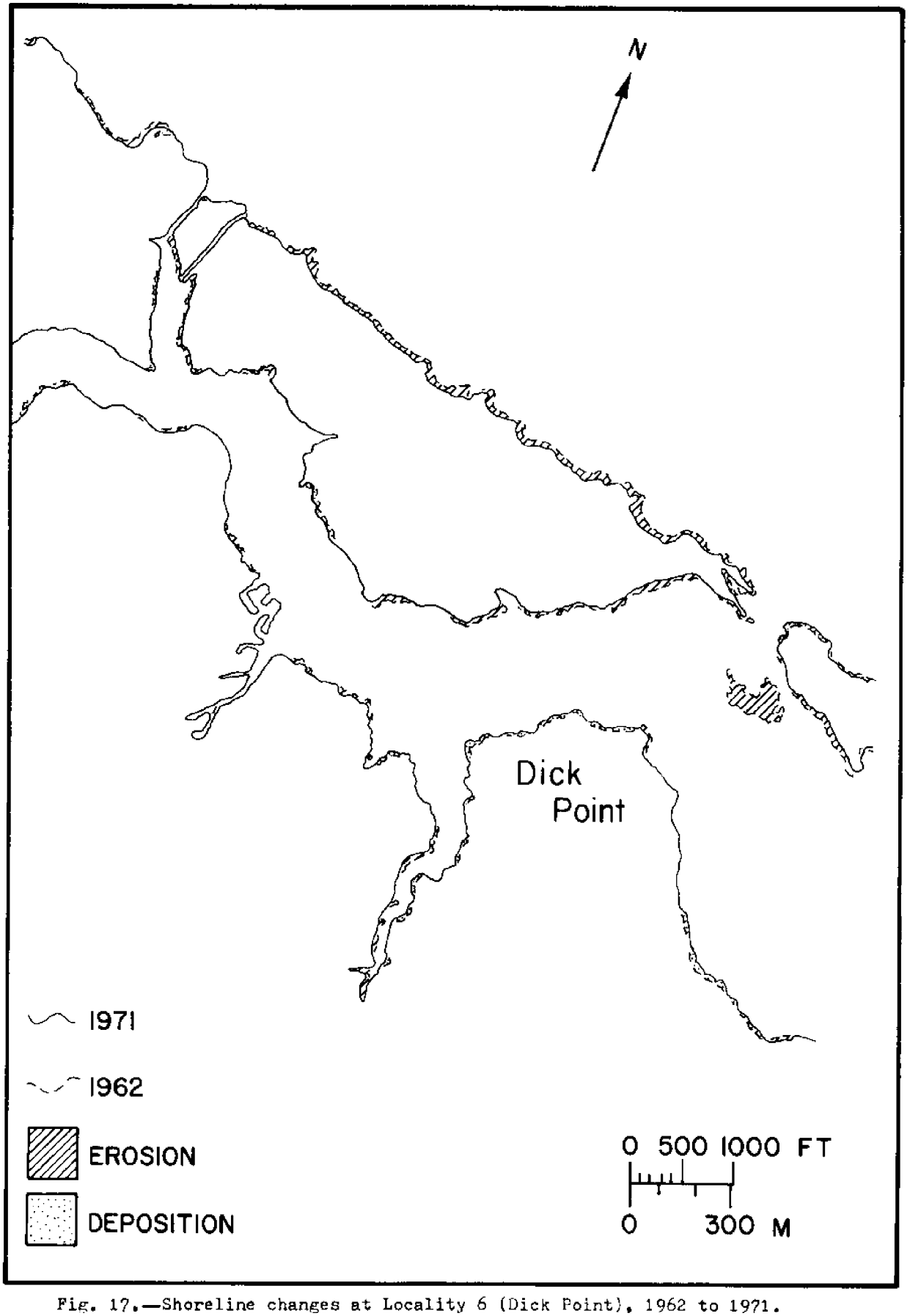


Fig. 17.—Shoreline changes at Locality 6 (Dick Point), 1962 to 1971.

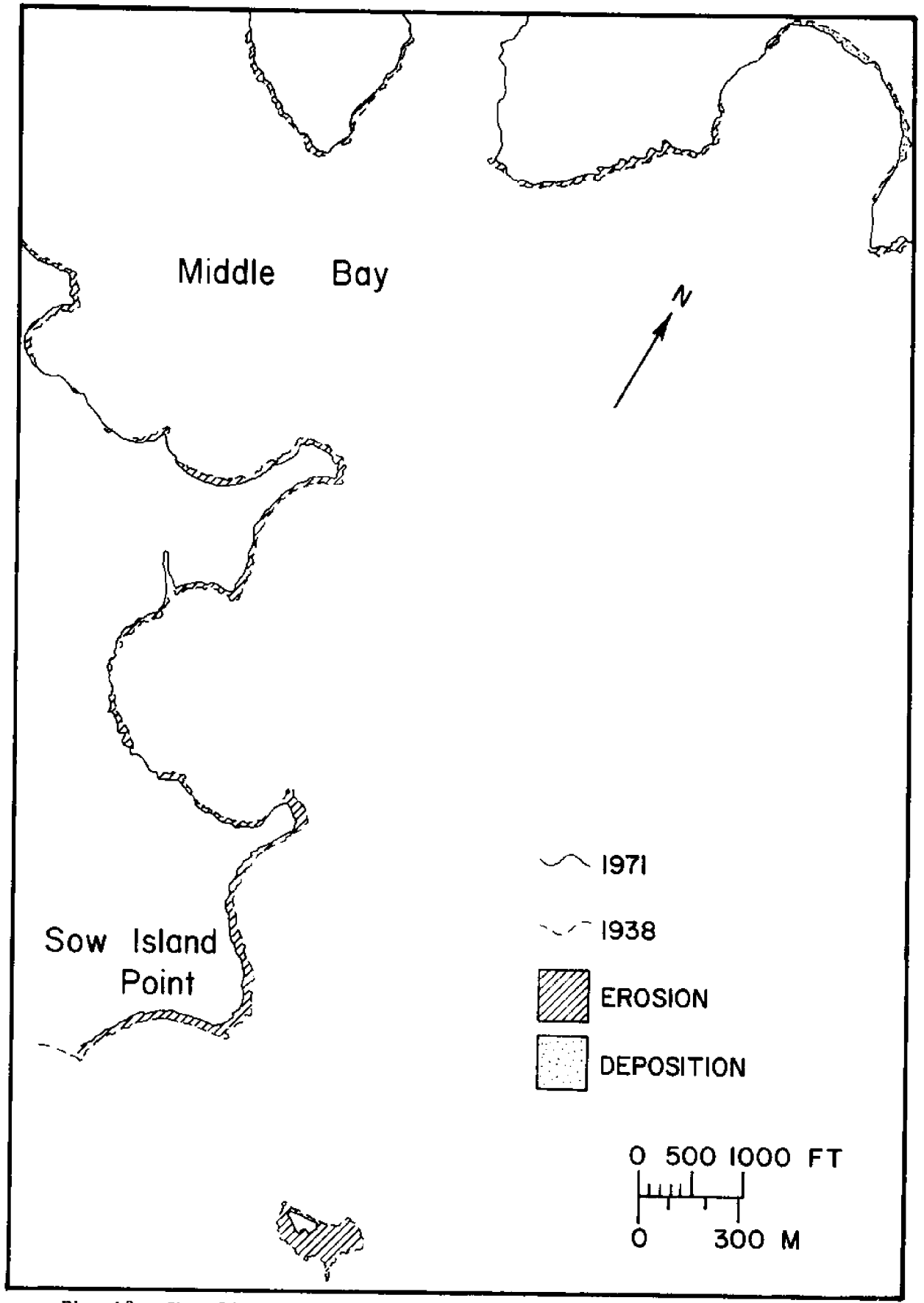


Fig. 18.—Shoreline changes at Locality 7 (Sow Island Point), 1938 to 1971.

Sow Island Point was reduced to about one-quarter of its initial size between 1938 and 1971. Figure 18 illustrates that most erosional activity has been concentrated on the southwestern side of Middle Bay rather than along the northeastern side.

Locality 8 at Maw Point had net erosion between 1938 and 1971 at maximum rates up to 3 feet per year (Fig. 19). Fully 95 percent of the shoreline shows net erosion between these dates, and less than 5 percent shows net deposition. Strong erosion is also indicated between 1938 and 1962 (Fig. 20) and between 1962 and 1971 (Fig. 21), although less than 10 percent of the shoreline illustrates deposition between 1962 and 1971.

Locality 9, at Point of Marsh across the Neuse River from Maw Point, had erosion rates up to 3.5 feet per year. Approximately 80 percent of the shoreline shows net erosion between 1939 and 1971 while the remainder of the shoreline indicated little change (Fig. 22). The largest amount of erosion is concentrated along Point of Marsh. The shoreline southeast of Point of Marsh is at least partially protected from wave activity by a marshy island (Raccoon Island) in the sound some 1000-1200 yards off the marshy shoreline (Fig. 1).

Locality 10 at Cedar Island illustrates well the localized effects on erosion and deposition which are produced by man-made features

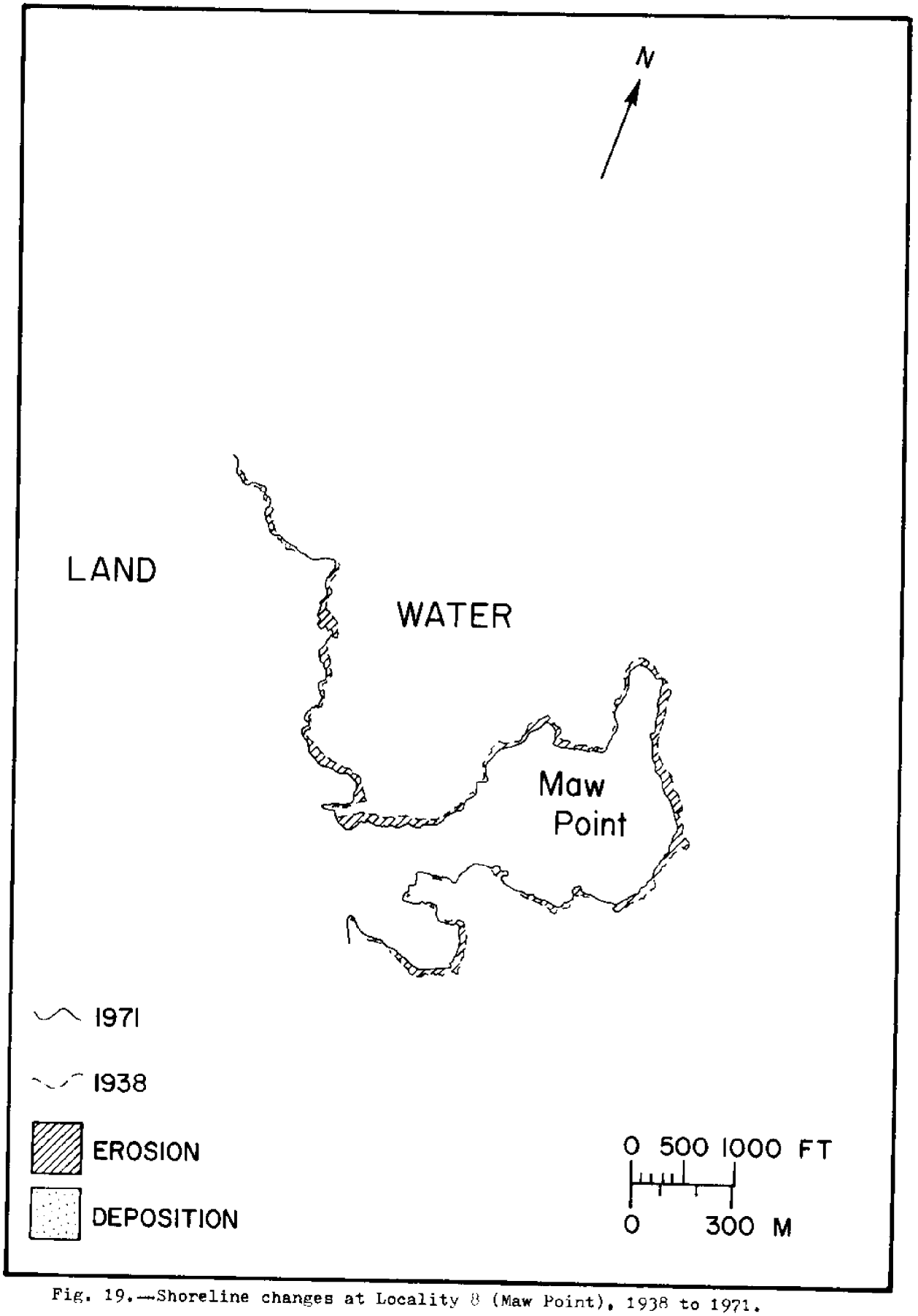


Fig. 19.—Shoreline changes at Locality 8 (Maw Point), 1938 to 1971.

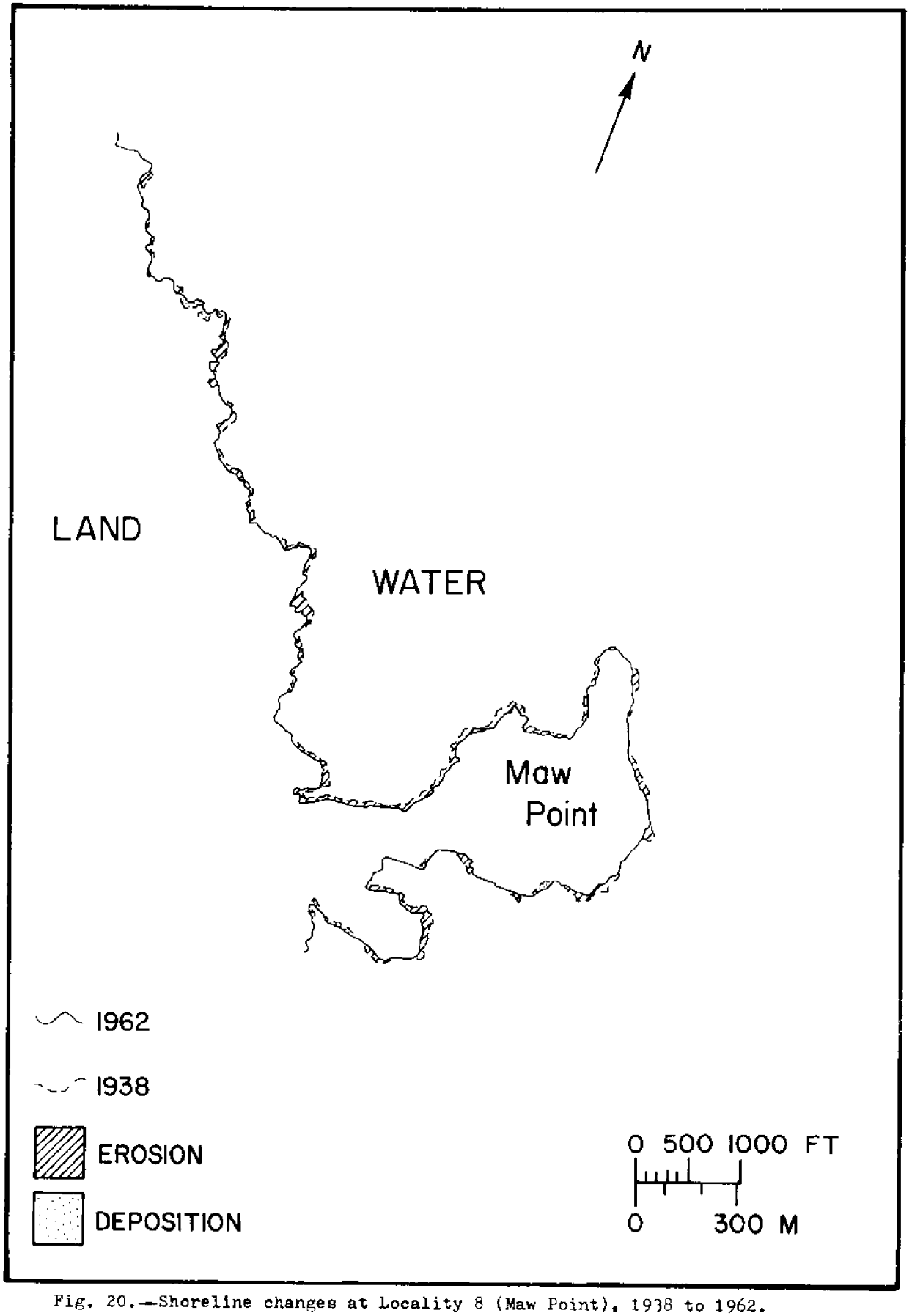


Fig. 20.—Shoreline changes at Locality 8 (Maw Point), 1938 to 1962.

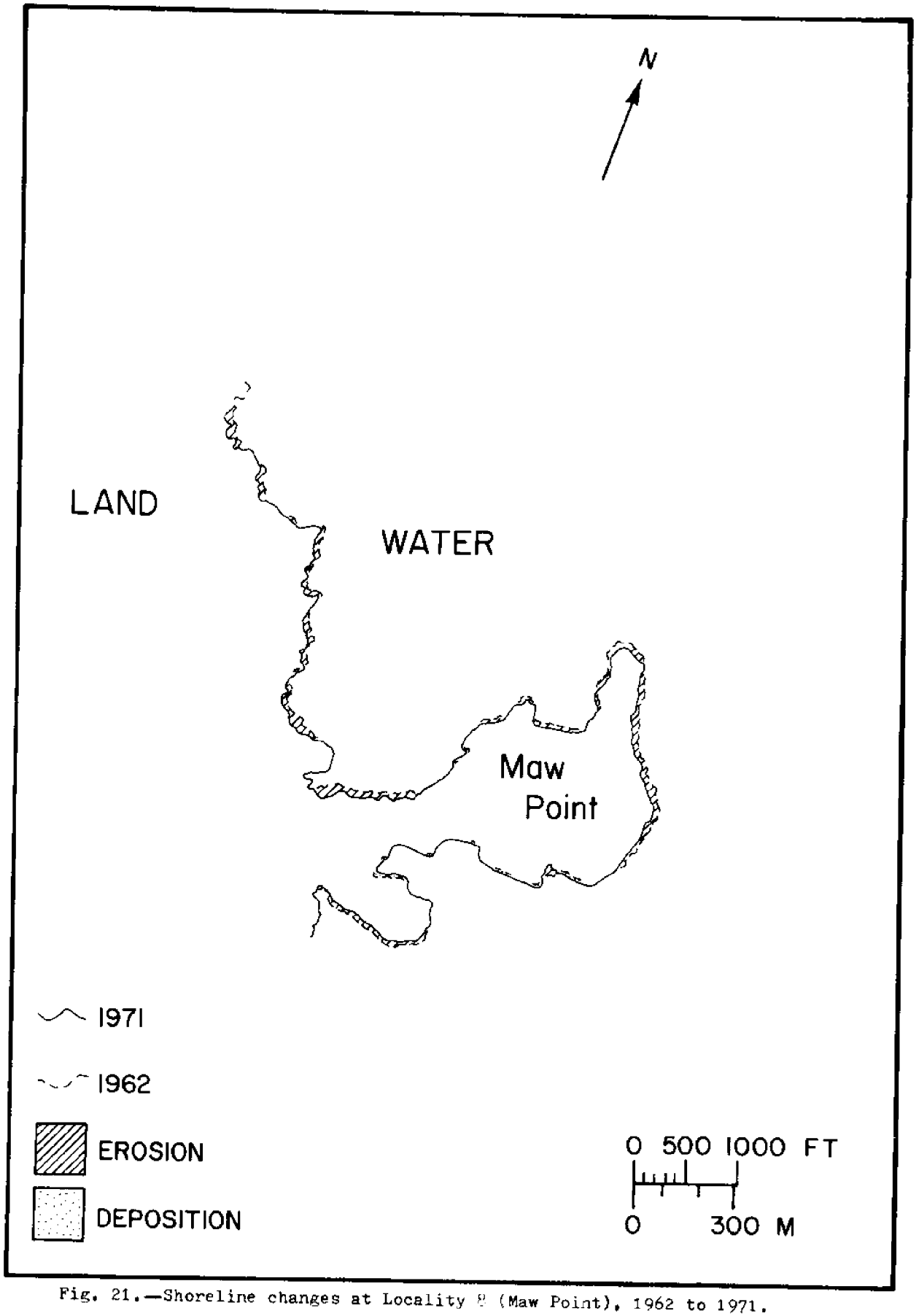


Fig. 21.—Shoreline changes at Locality 8 (Maw Point), 1962 to 1971.

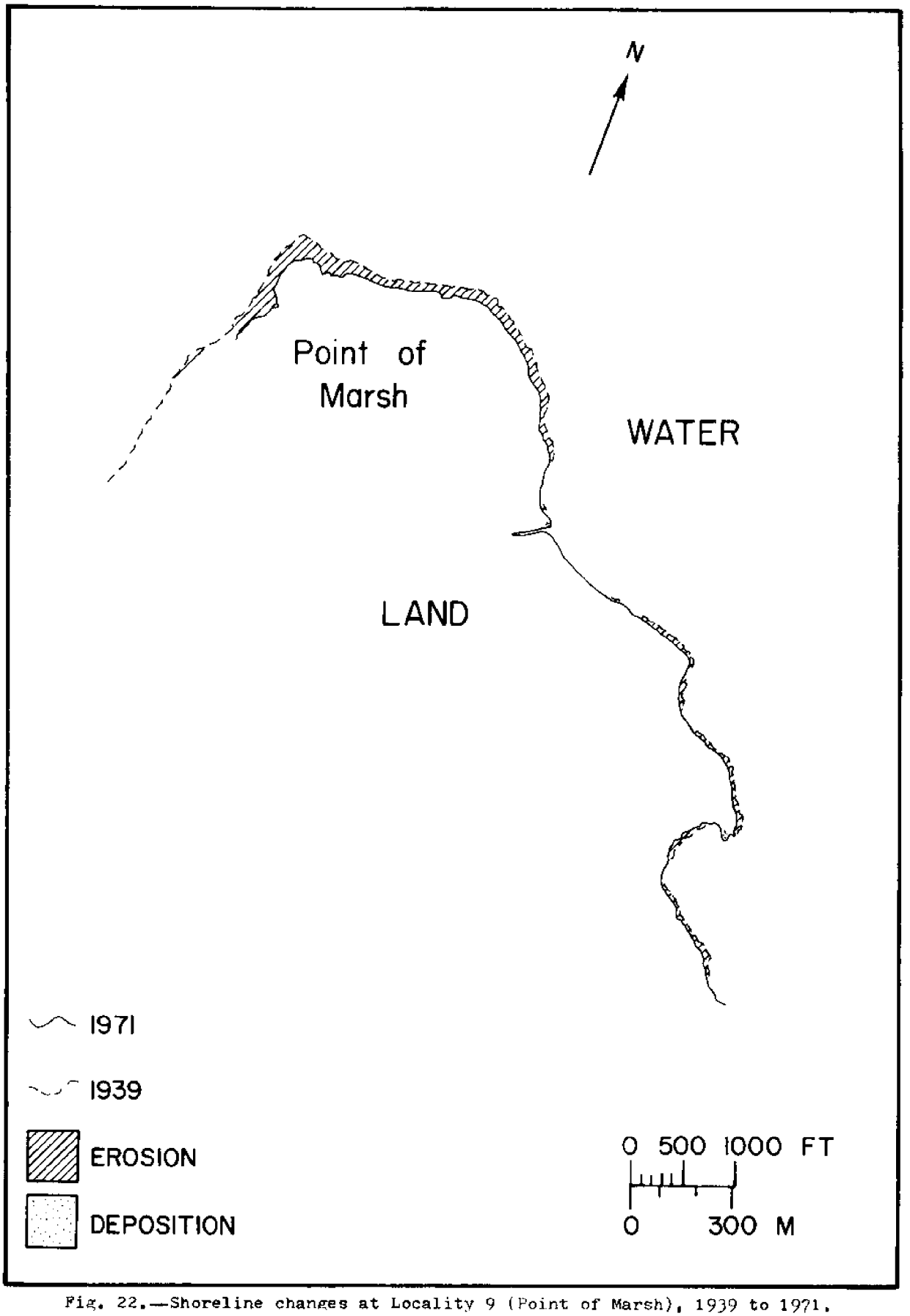


Fig. 22.—Shoreline changes at Locality 9 (Point of Marsh), 1939 to 1971.

blocking the sediment supply. Position and shape of the shoreline have been strongly altered by the location of a ferry terminal as shown in Figure 23. Between 1945 and 1971 the terminal breakwater has resulted in progradation of the shoreline southeast of the terminal and "starvation" and erosion of the shoreline to the northwest (Fig. 23). The northwest movement of sand indicated is likely produced by currents passing through the barrier island system at a point southeast of L10 (Fig. 1) and by winds from the east and northeast. About 60 percent of the shoreline at L10 has experienced net erosion at rates up to 6 feet per year due to the combined effects of diminished sand supply and wave activity in the sound. Some minor deposition is indicated in North Bay, but the strongest net deposition has occured along the unsheltered shoreline and is the result of the damming of sediment supply lines by the ferry terminal breakwater. As shown by Figure 23, approximately 40 percent of the shoreline at L10 experienced net deposition between 1945 and 1971. This locality is the first which has shown prominent lengths of relatively wide sandy beach and numerous strong sandy shoals. The occurrence of much sand from an apparent southeastward source at this locality suggests that sand commonly is supplied to the sound through inlets in the barrier island system.

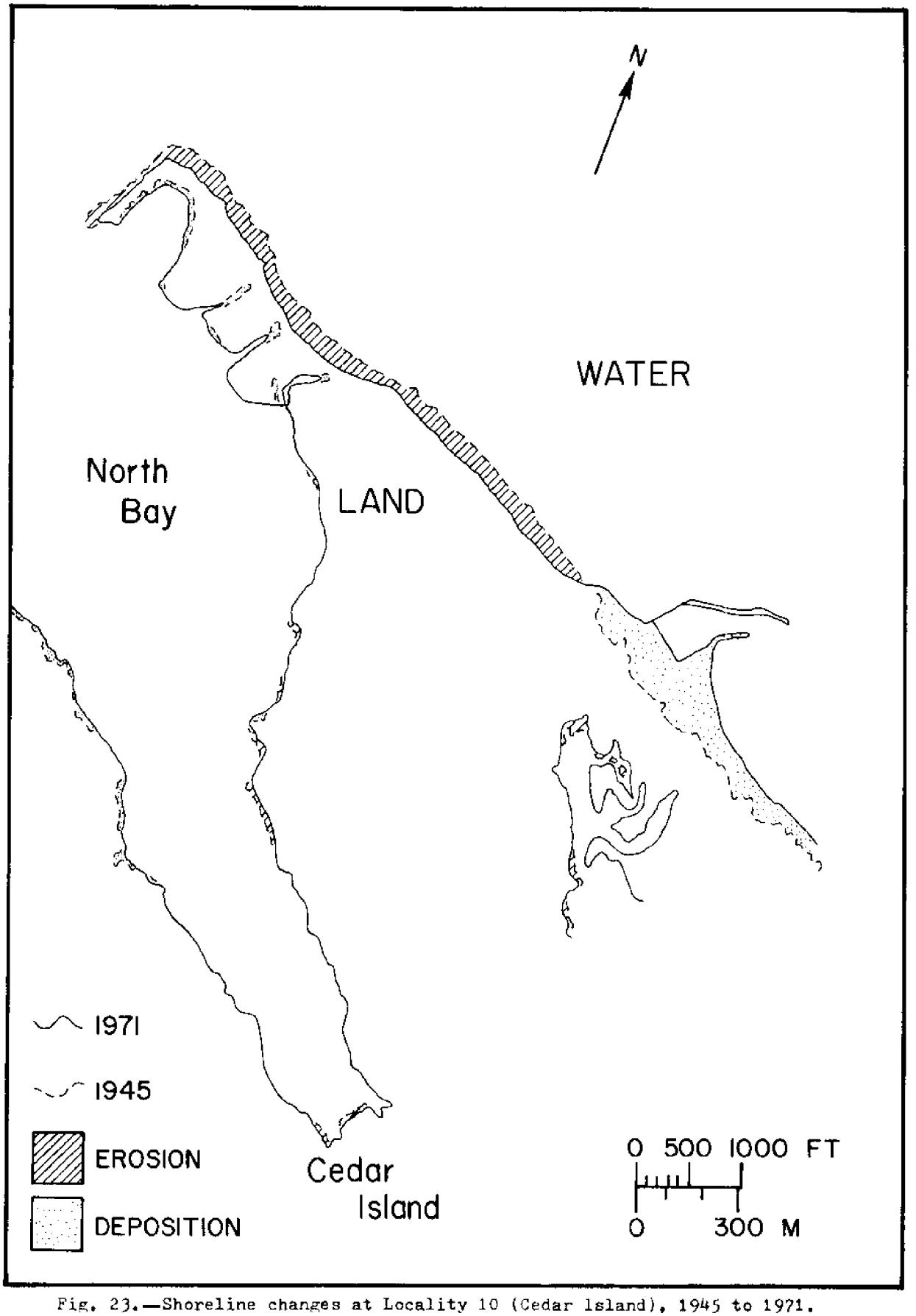


Fig. 23.—Shoreline changes at Locality 10 (Cedar Island), 1945 to 1971.

B. Barrier Island Side of Pamlico Sound

Localities 11 through 15 are located along the Outer Banks, a barrier island system (Fig. 1).

Locality 11, near Ocracoke Inlet, illustrates the effects of hurricane activity along both the lagoonal and oceanward sides of the barrier island system. Since some of the aerial photographs at L11 were taken shortly after hurricane activity, the land - water boundary on the photographs was sometimes marked by a relatively diffuse line. Therefore, the high water line was used for shoreline comparisons at this locality in an attempt to more accurately delineate changes in shoreline morphology.

Figure 24 may illustrate an exaggerated pattern of net erosion for the lagoonal shorelines at Locality 11 between 1945 and 1971. The 1945 lagoonward shoreline was drawn from an aerial photograph taken about 4½ months after a hurricane from the south which moved considerable amounts of sand lagoonward across the barrier island. The post-hurricane high water line from the 1945 aerial photograph is cut into the washover fans, which indicates that erosional activity within the sound is modifying the sand shifted lagoonward by the hurricane. Such erosion following storm washover is probably normal, and is also suggested at L11 (Fig. 28) between a March 1962 storm and May 1962. The 1971 lagoonward shoreline does not show effects of a recent hurricane and may be closer to the form and position of the

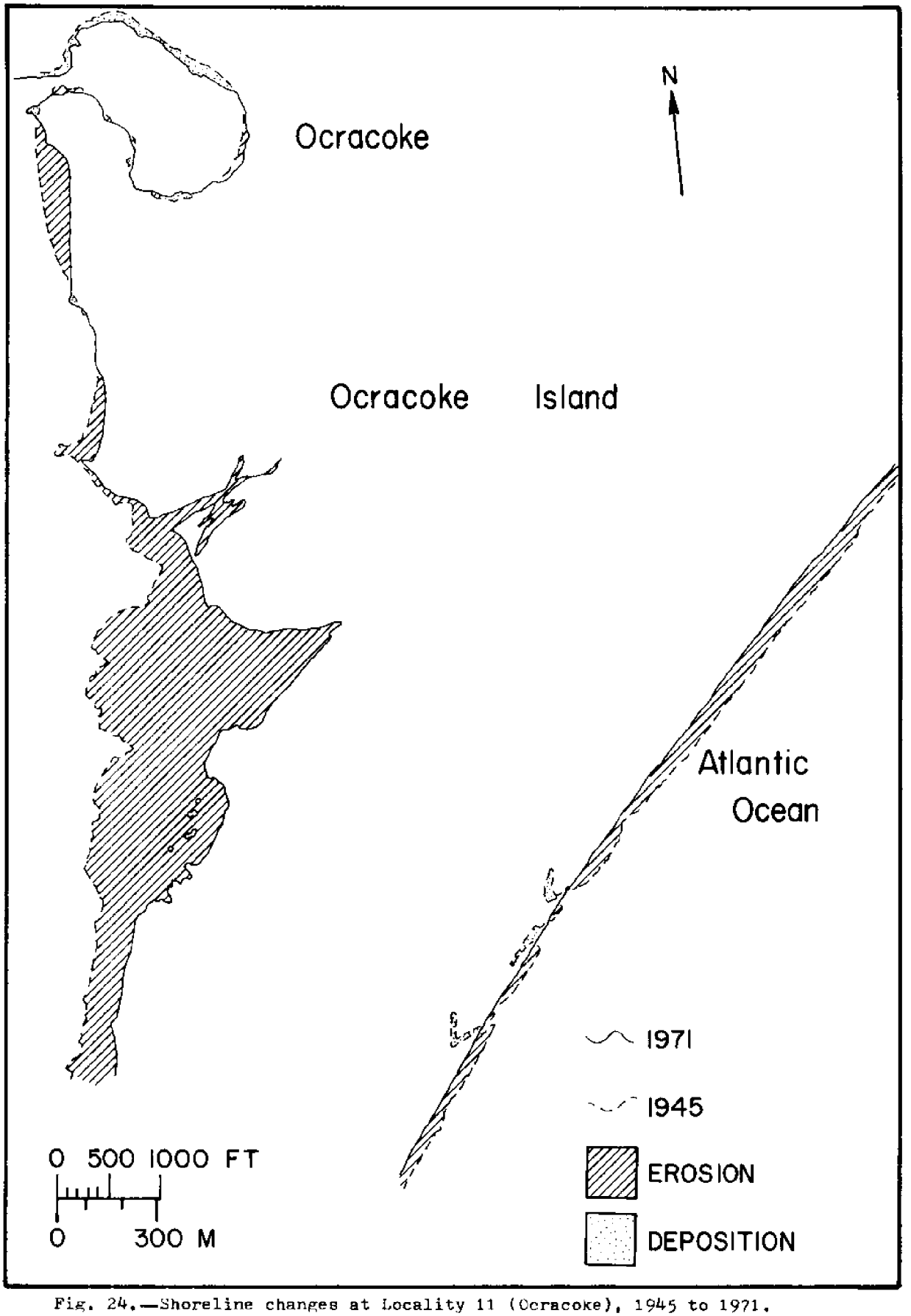


Fig. 24.—Shoreline changes at Locality 11 (Ocracoke), 1945 to 1971.

mean shoreline. This suggestion is strengthened by the shorelines for 1953, 1955, 1962S, 1962, and 1968 (Figs. 26-30), all of which show morphology and position similar to that noted for the 1971 shoreline. The erosional effects indicated between 1945 and 1953 (Fig. 25) also may be exaggerated for the same reason

A comparison of the 1953 and 1971 lagoonal shoreline at Locality 11 (Fig. 31) reveals a similar morphology for both dates plus an erosion area considerably less extensive than for either 1945 and 1971 (Fig. 24) or 1945 and 1953 (Fig. 25) It appears that any mean change for the lagoonal shoreline derived from a comparison of 1945 and 1971 or 1945 and 1953 shorelines is probably inaccurate because of hurricane effects Net erosion derived from 1953 and 1971 shorelines (Fig. 31) provides maximum localized erosion rates up to 11 feet per year on the lagoonal side of the barrier island system at L11. Erosion has occured over approximately 90 percent of the lagoonal shoreline at this locality between 1953 and 1971 (Fig. 31); net deposition for this period is indicated for less than 10 percent of the shoreline.

The oceanward side of the barrier island system is not susceptible to the washover problems of the lagoonal side, and a comparison of the 1945 and 1971 shorelines may be used to approximate mean conditions at Locality 11. Net erosion is shown for more than 95 percent of the oceanward shoreline between 1945 and 1971 (Fig. 24); net deposition is minor (less than 1 percent). Erosion rates up to at least 8 feet

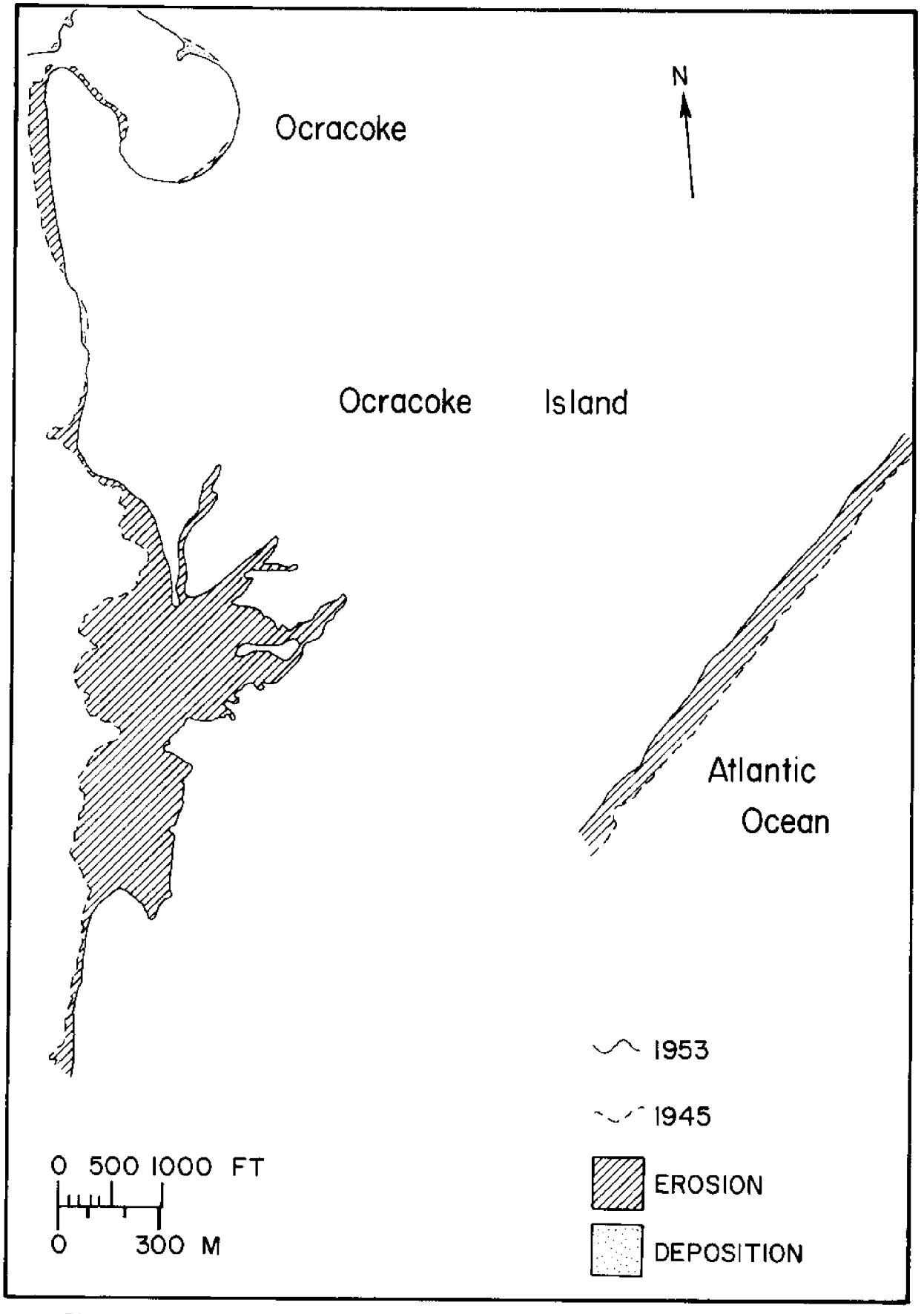


Fig. 25.—Shoreline changes at Locality 11 (Ocracoke), 1945 to 1953.

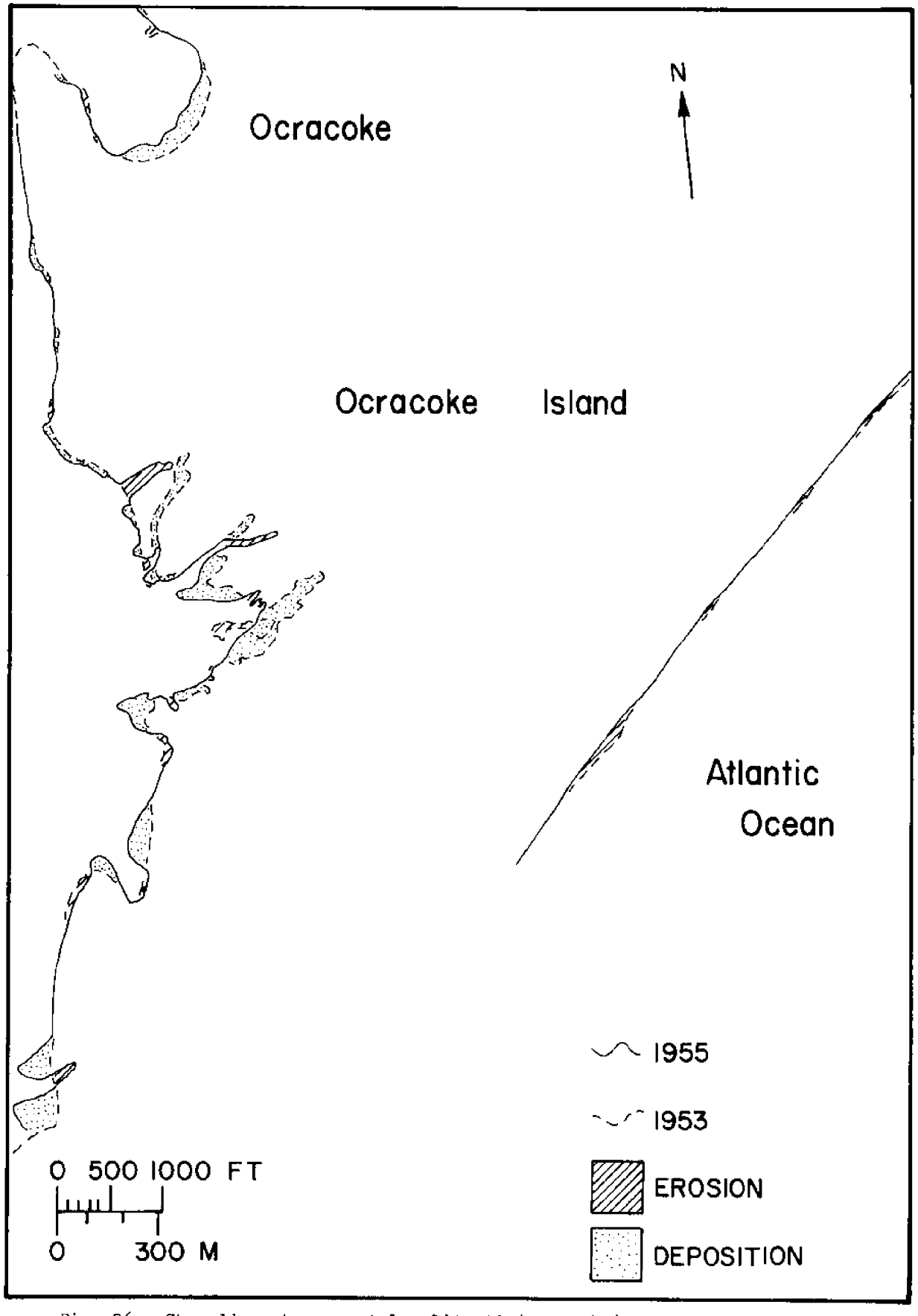


Fig. 26.—Shoreline changes at Locality 11 (Ocracoke), 1953 to 1955.

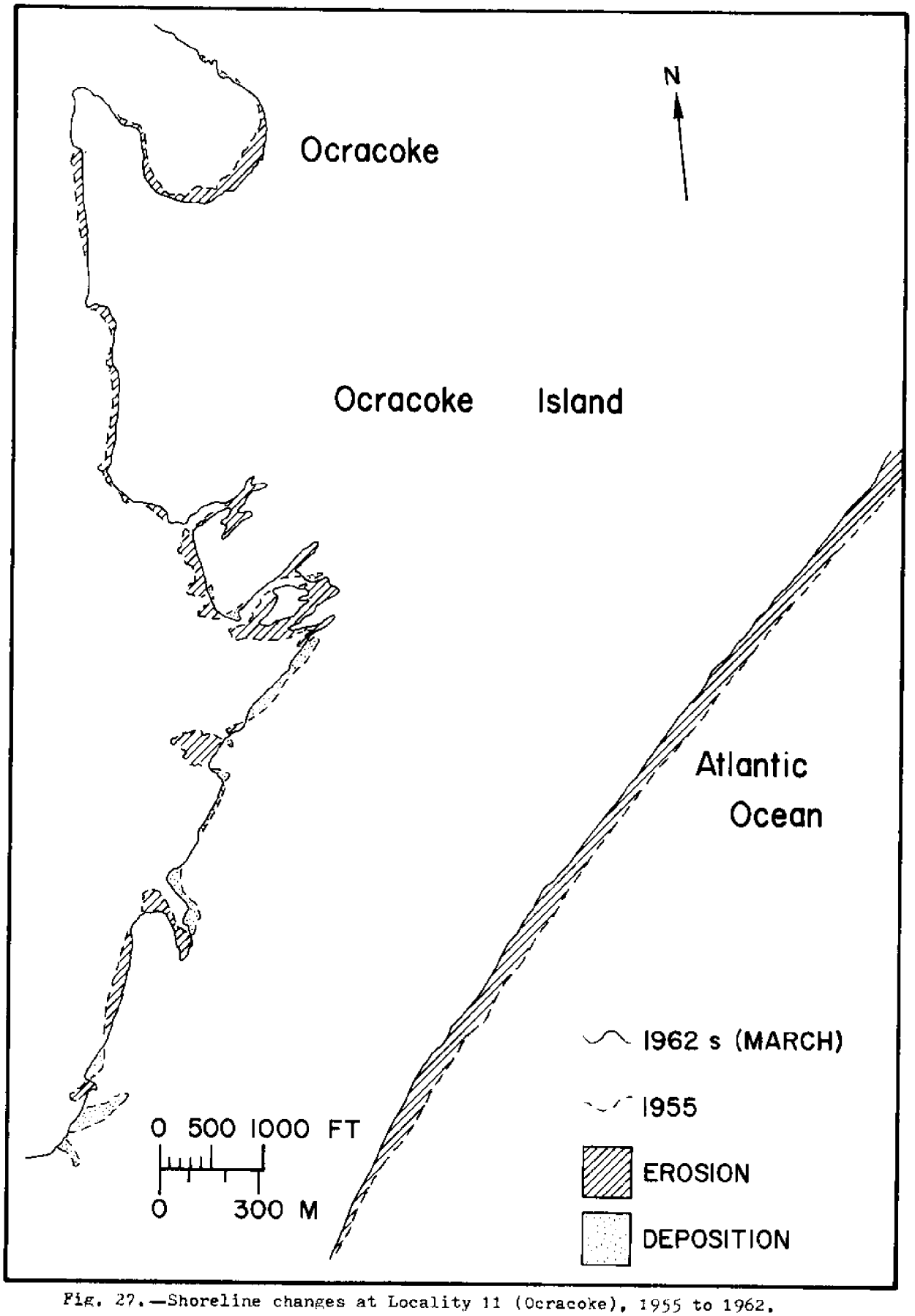


Fig. 27.—Shoreline changes at Locality 11 (Ocracoke), 1955 to 1962.

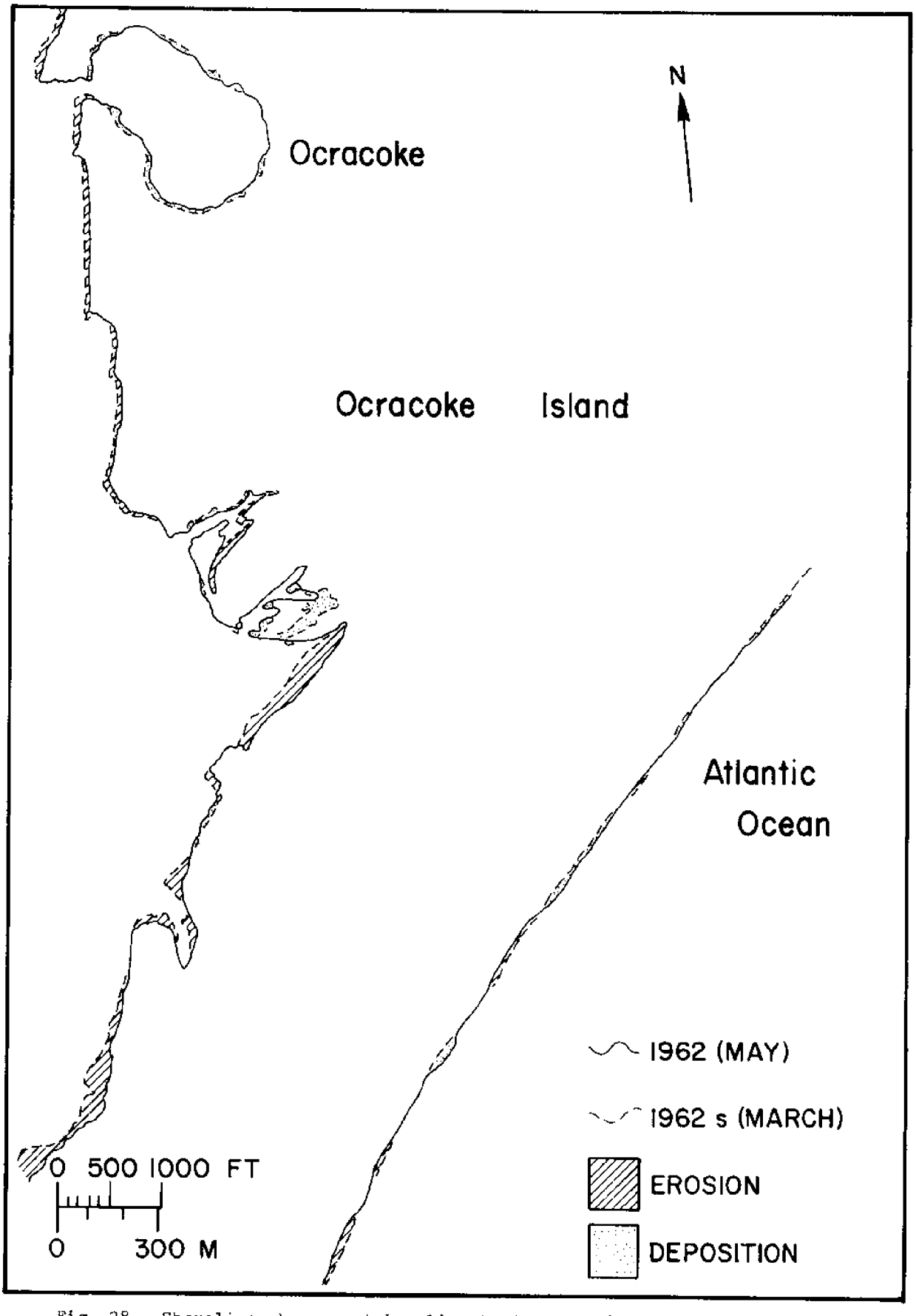


Fig. 28.—Shoreline changes at Locality 11 (Ocracoke), March to May, 1962.

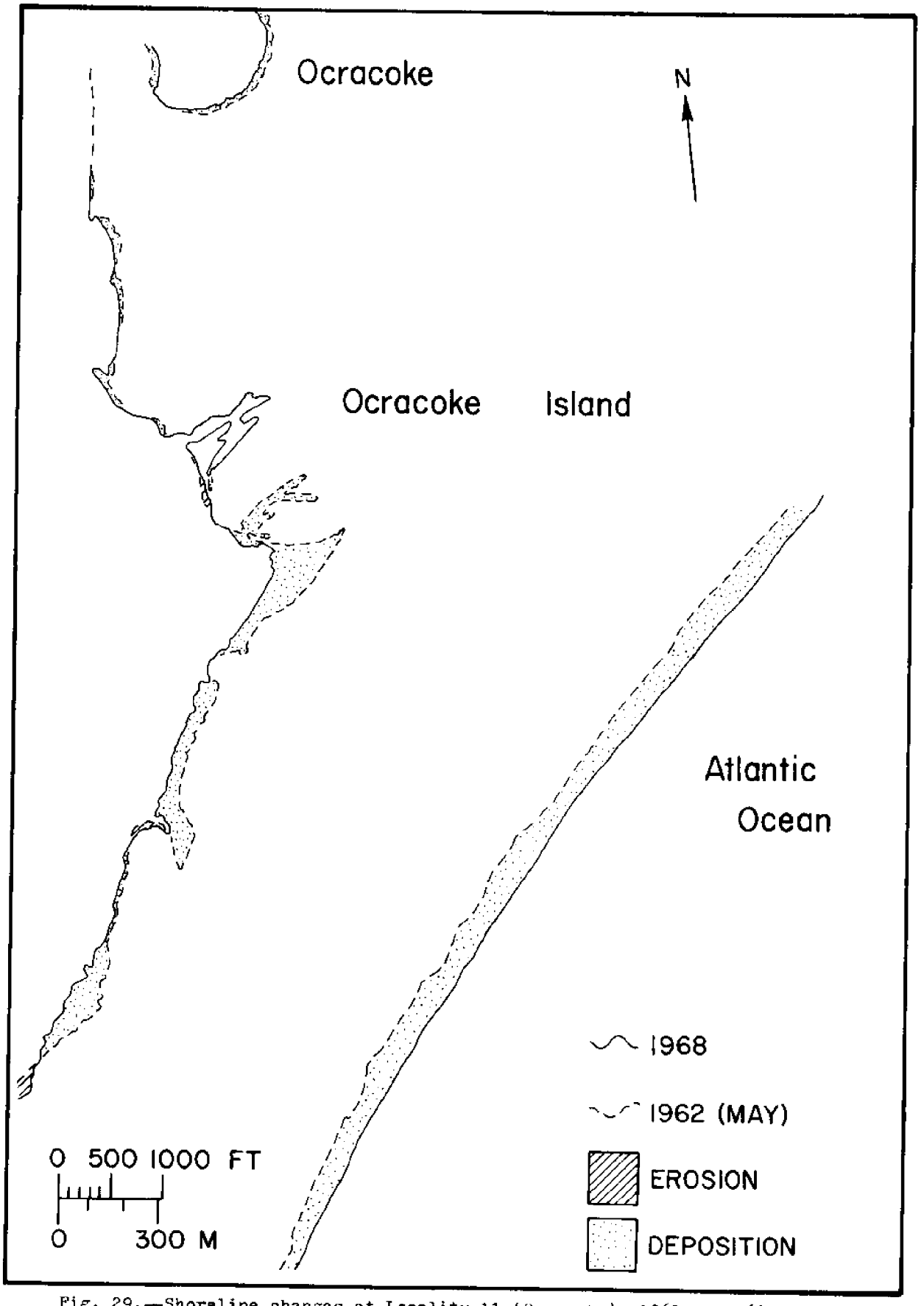


Fig. 29.—Shoreline changes at Locality 11 (Ocracoke), 1962 to 1968.

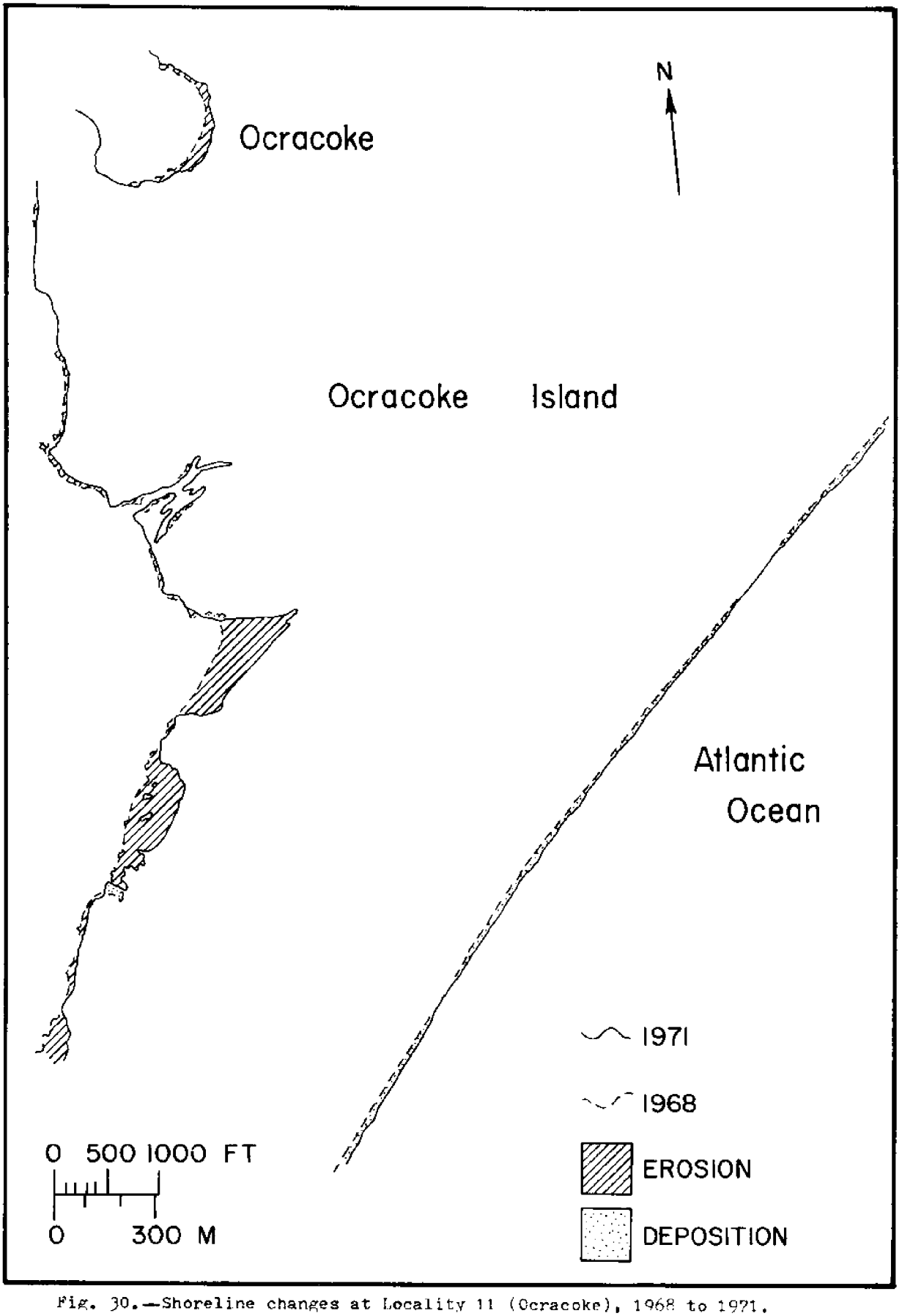


Fig. 30.—Shoreline changes at Locality 11 (Ocracoke), 1968 to 1971.

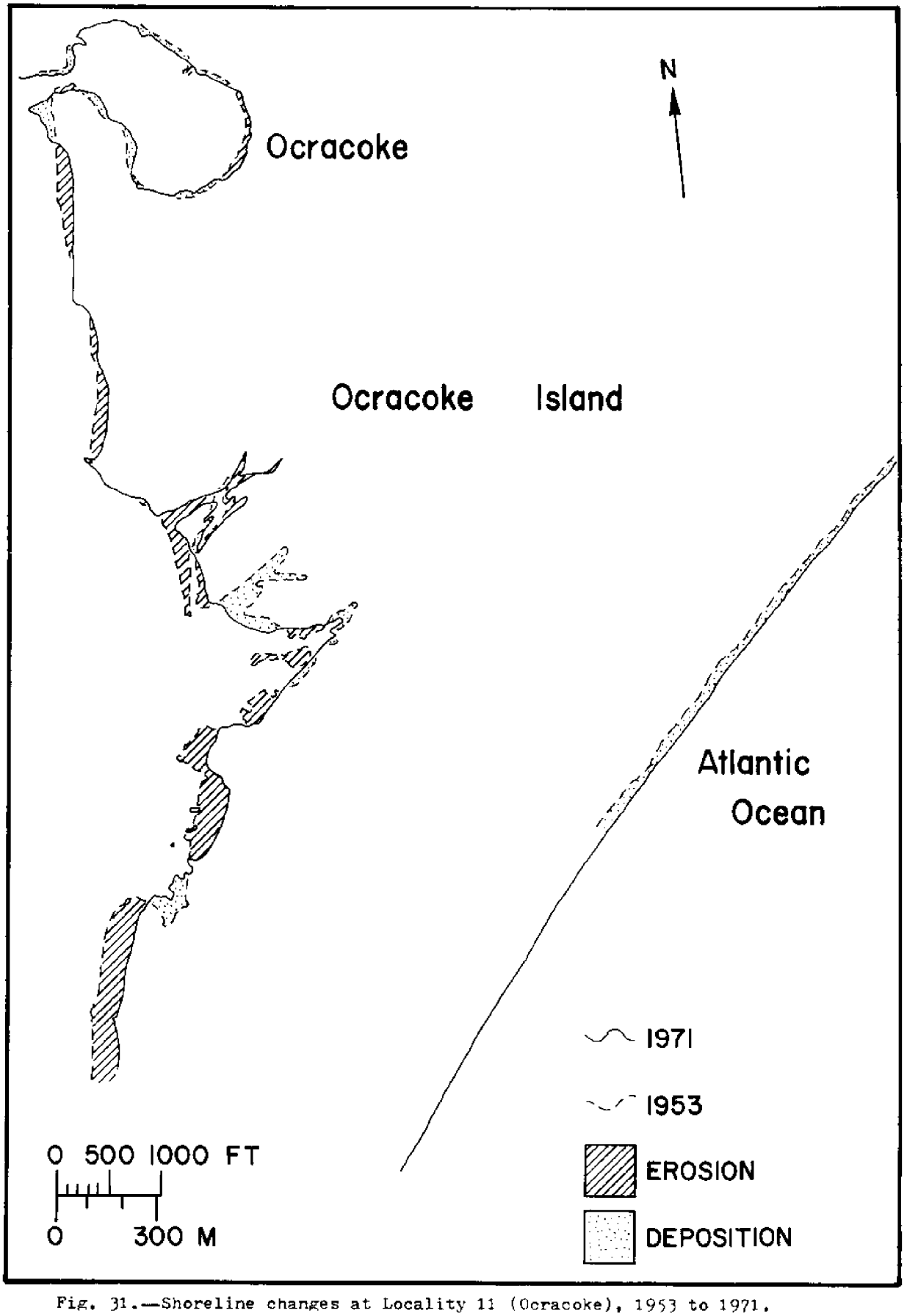


Fig. 31.—Shoreline changes at Locality 11 (Ocracoke), 1953 to 1971.

per year are suggested between 1945 and 1971. Much of the erosion of the oceanward shoreline appears related to hurricane activity, and localized short-term rates as high as 20 feet per year are indicated between 1955 and 1962S (Fig. 27) due to the March 1962 hurricane. These values indicate variability in erosion rates produced by hurricane activity and illustrate that a mean erosion rate or an "average" percentage of erosion/deposition is difficult to establish where hurricane activity has had a strong influence on morphology of the shoreline. There is a good indication from Figures 28 and 29 that prograding and/or smoothing of the oceanward side of the barrier island system may occur soon after hurricane activity due to the influence of longshore currents.

Locality 12, situated near Buxton and Cape Hatteras, includes the segment of beach upon which Hatteras lighthouse is located. Figure 32 shows that 75 percent of the shoreline of the lagoonal side of the barrier system experienced net erosion between 1959 and 1971 and 25 percent experienced net deposition. Local maximum rates of erosion as high as 8 feet per year are indicated. Emplacement of two groins along the ocean beach near Hatteras lighthouse appears to have reduced the rate of erosion of the beach southwest of the groins (Fig. 32). However, immediately northeast of the groins maximum erosion rates up to 16 feet per year are still indicated. Greater than 95 percent of the oceanward shoreline shows net erosion between 1959 and 1971 at L12;

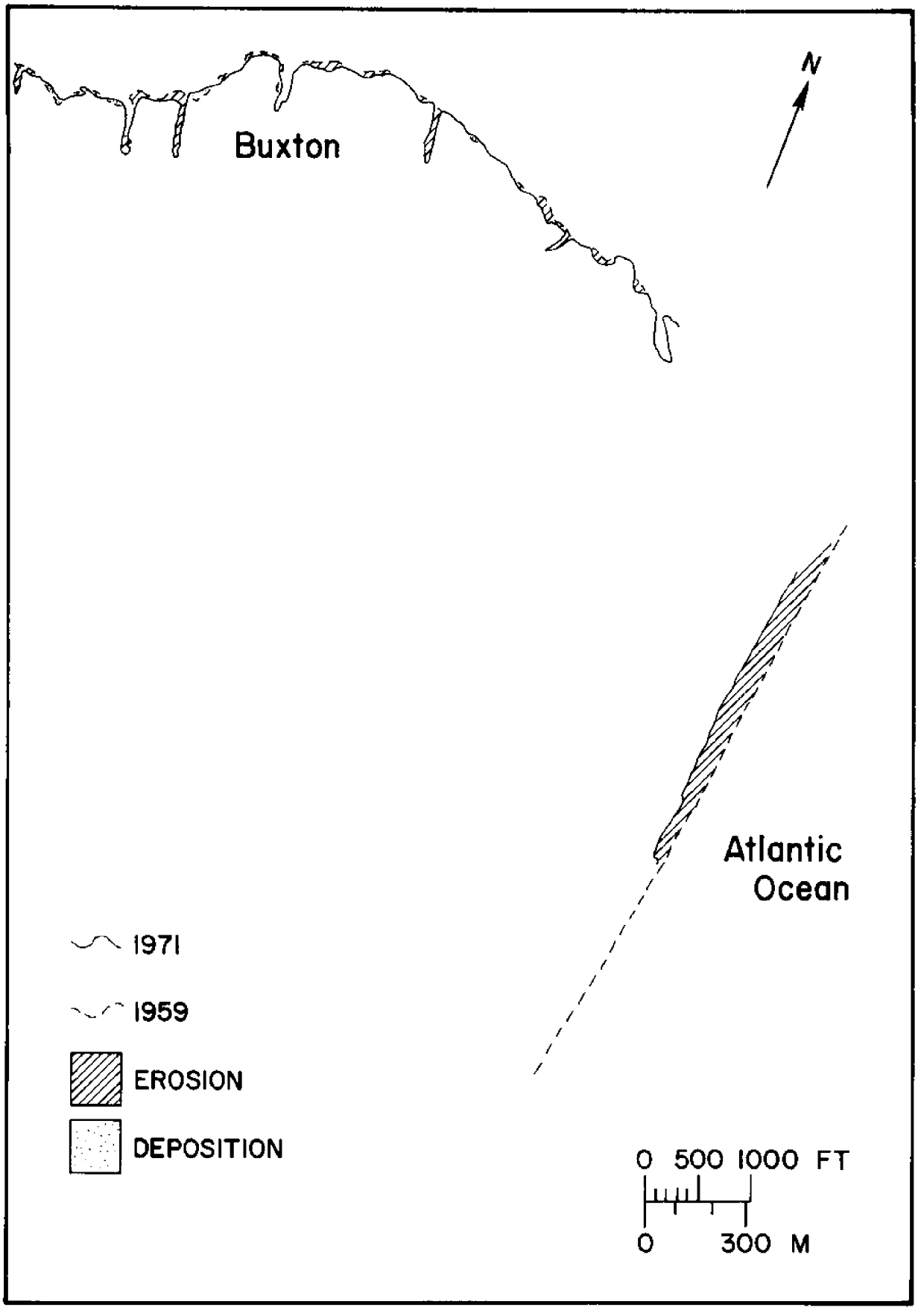


Fig. 32.—Shoreline changes at Locality 12 (Buxton), 1959 to 1971.

no net deposition is obvious. The groins have slowed, but not reversed, the erosional processes at this locality.

Locality 13 (Avon) shows net erosion over 95 percent of the lagoonal shoreline, and net deposition over the remaining 5 percent between 1945 and 1971 (Fig. 33). Local erosion rates up to 7 5 feet per year are indicated. The oceanward shoreline reflects erosional changes over the length of shoreline analyzed at L13, and rates range from about 2.5 feet per year up to 9.5 feet per year (Fig. 33). The period between 1945 and 1953 (Fig. 34) shows a similar area of erosion along the oceanward shoreline and less erosion on the lagoonal side. Figure 35 illustrates that much of the shoreline between 1953 and 1955 experienced net deposition along both the lagoonal and oceanward sides of the barrier island. Erosional effects probably related to the March 1962 hurricane are indicated by a comparison of the shorelines between 1955 and 1962S (Fig. 36). Repair and smoothing out of the oceanward shoreline soon after the March 1962 storm is suggested by Figure 37. This repair process may also be reflected in the progradation of the oceanward shoreline between May 1962 and 1971 (Fig. 38). As already discussed, Locality 11 (Figs. 28 and 29) also appeared to indicate this repair process after the 1962 hurricane.

Locality 14 (Salvo) along the barrier island system shows that the lagoonal side of the barrier island experienced only small percentages of net erosion (less than 25 percent) and net deposition

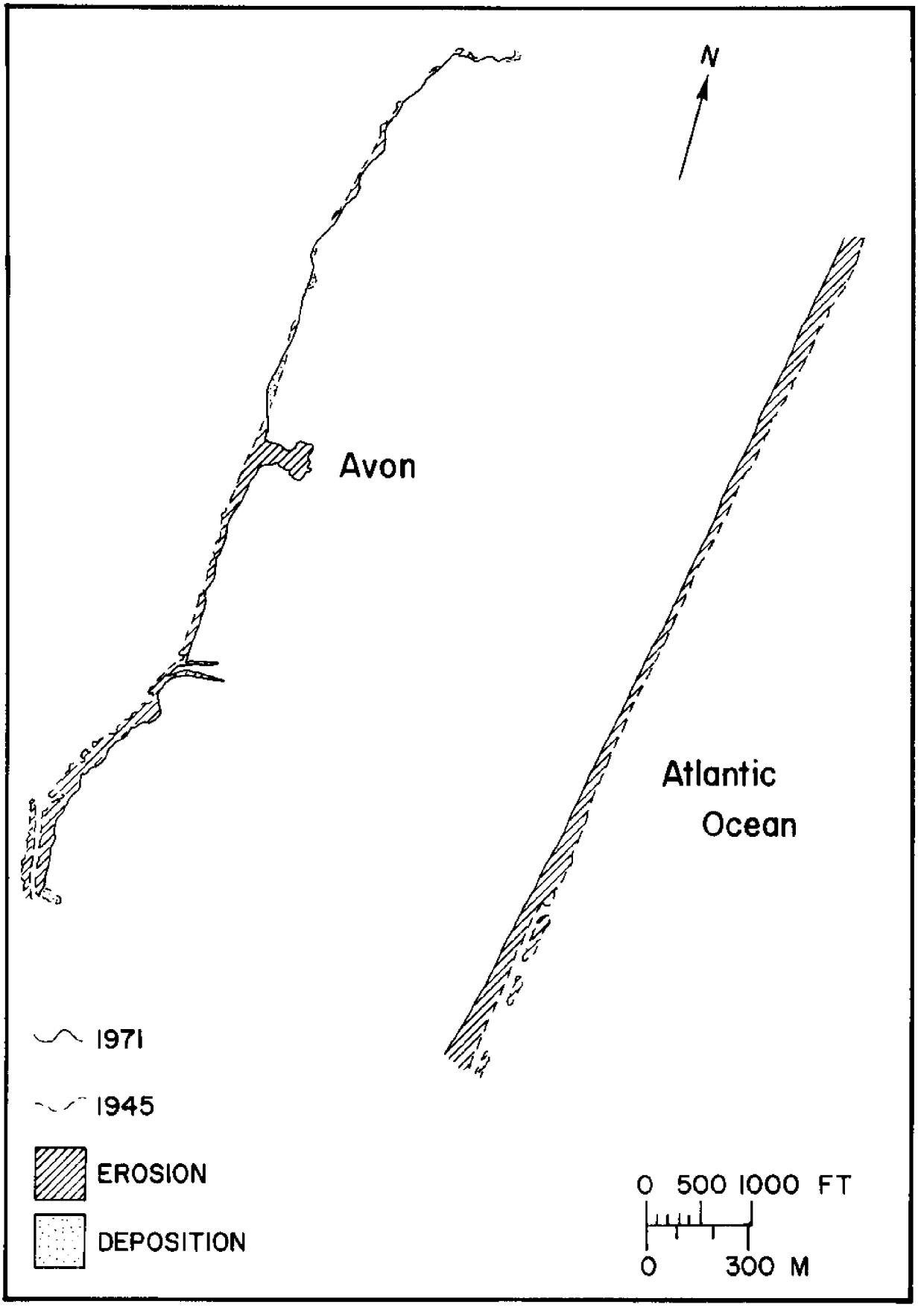


Fig. 33.—Shoreline changes at Locality 13 (Avon), 1945 to 1971.

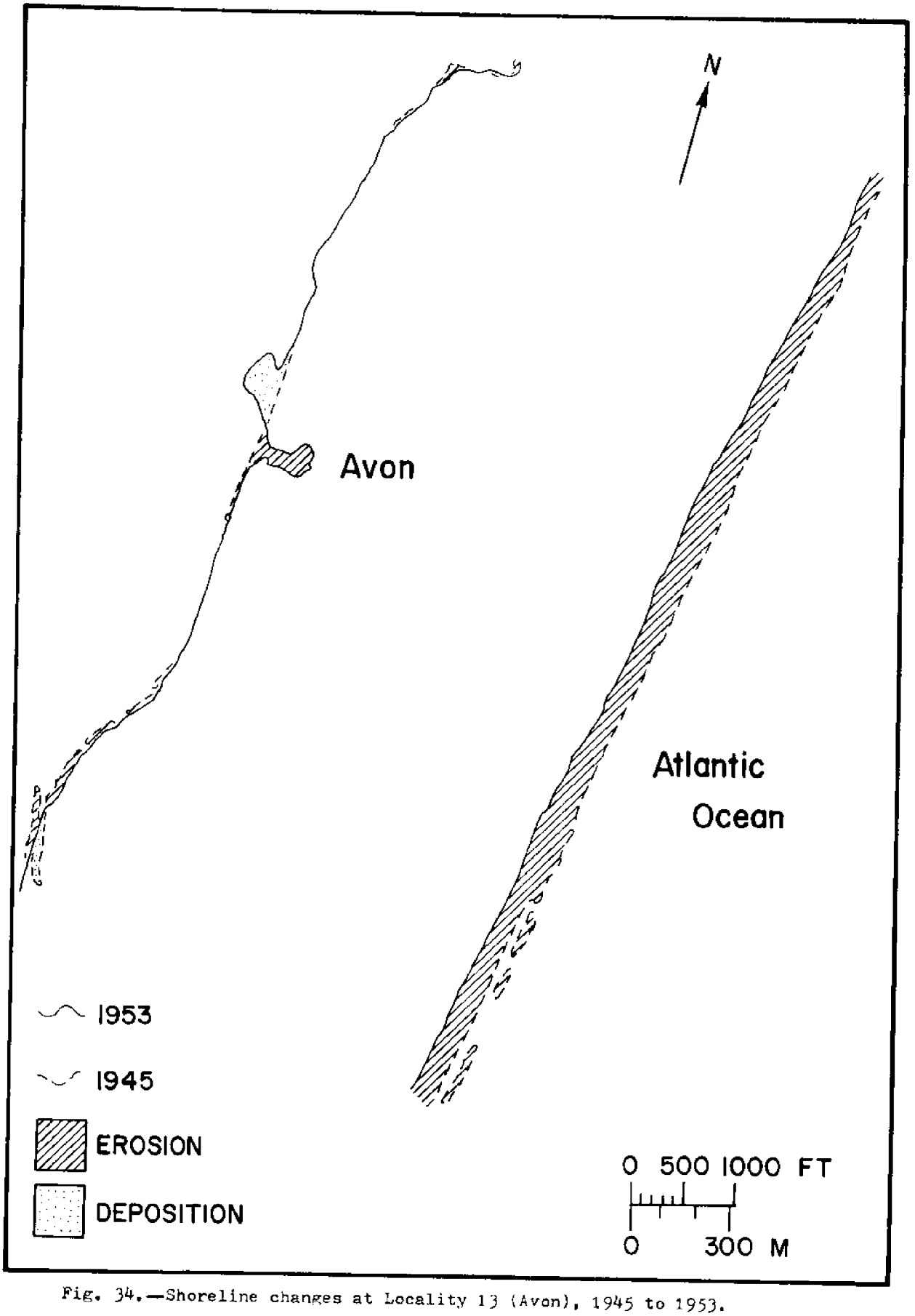


Fig. 34.—Shoreline changes at Locality 13 (Avon), 1945 to 1953.

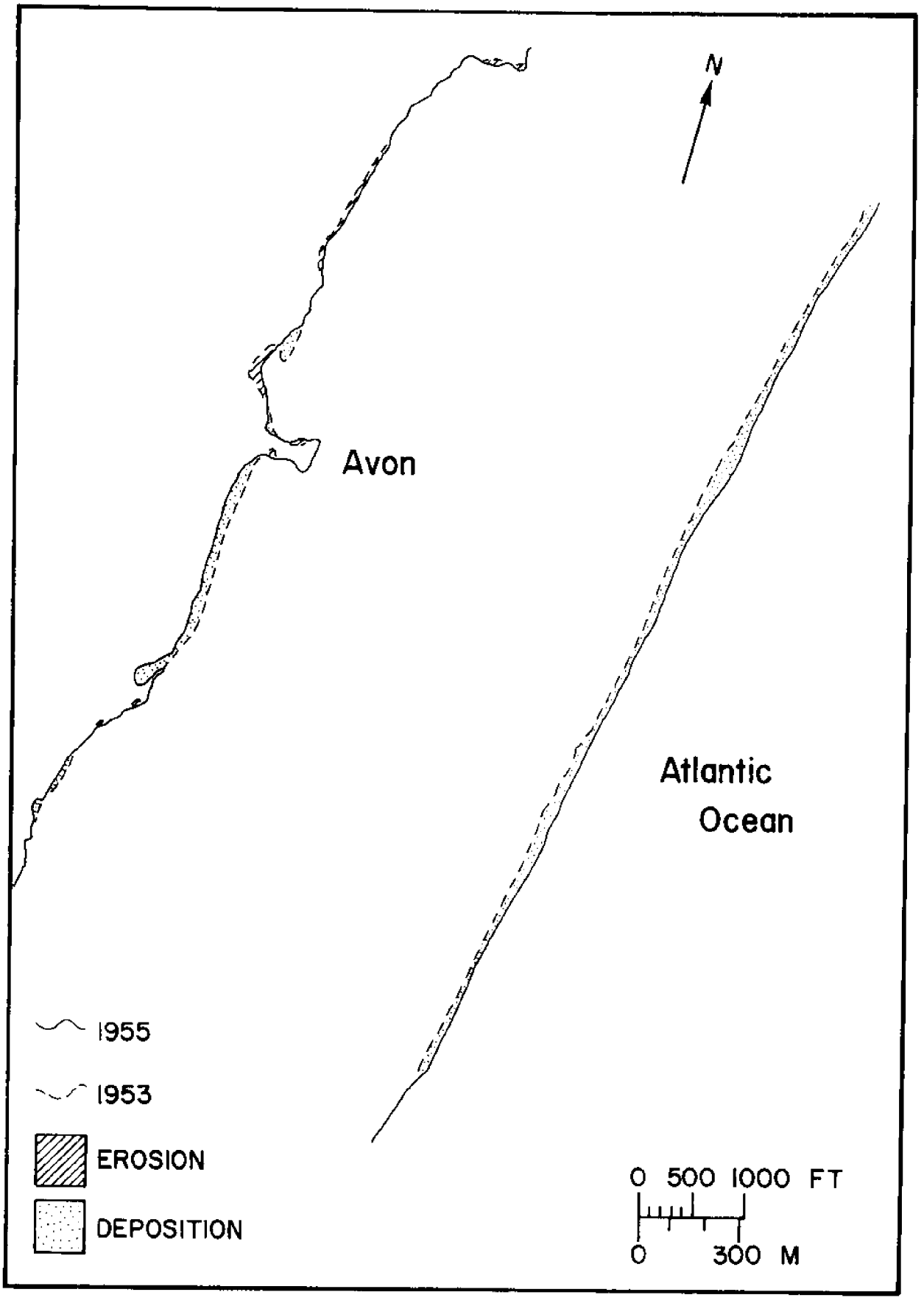


Fig. 35.—Shoreline changes at Locality 13 (Avon), 1953 to 1955.

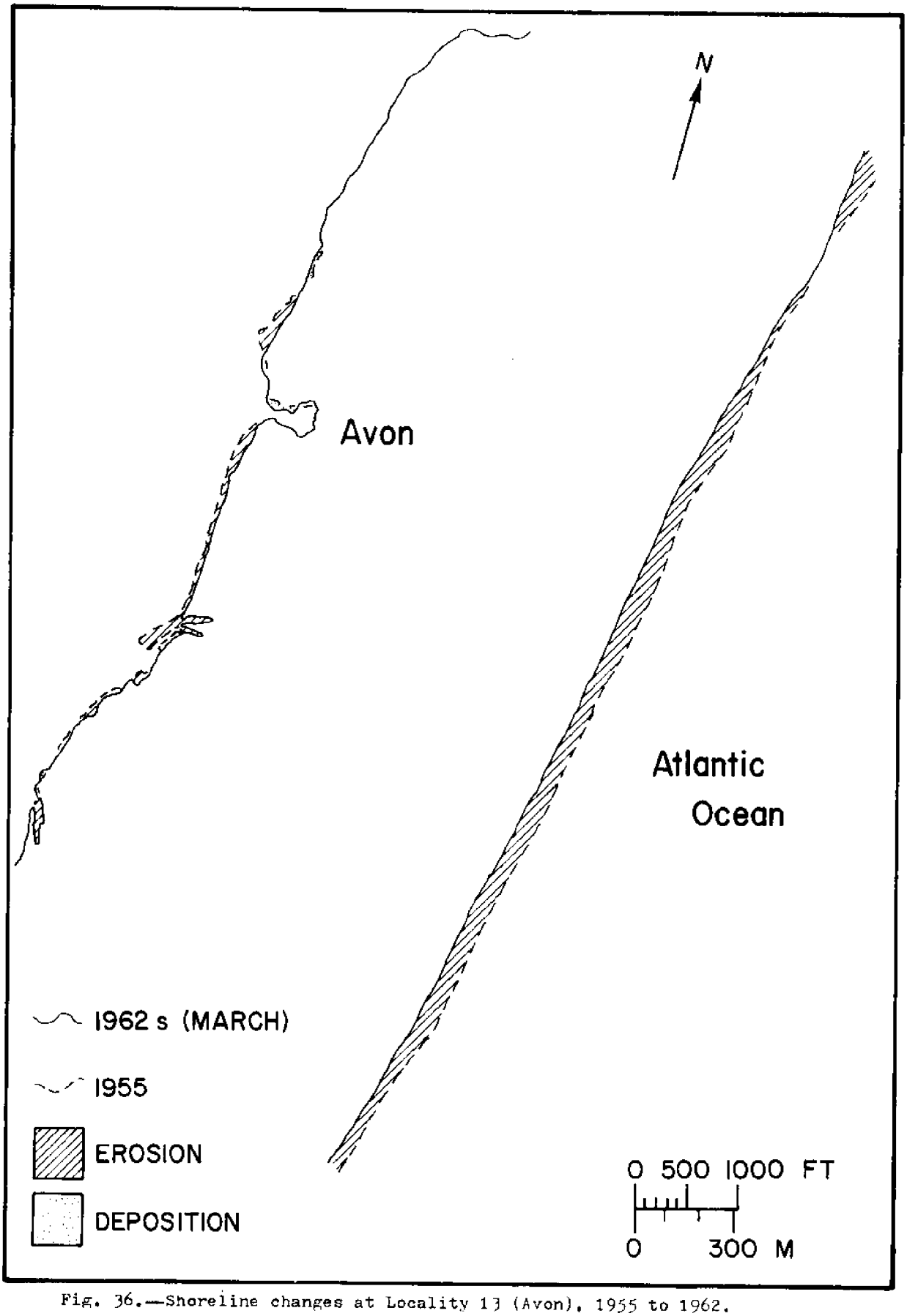


Fig. 36.—Shoreline changes at Locality 13 (Avon), 1955 to 1962.

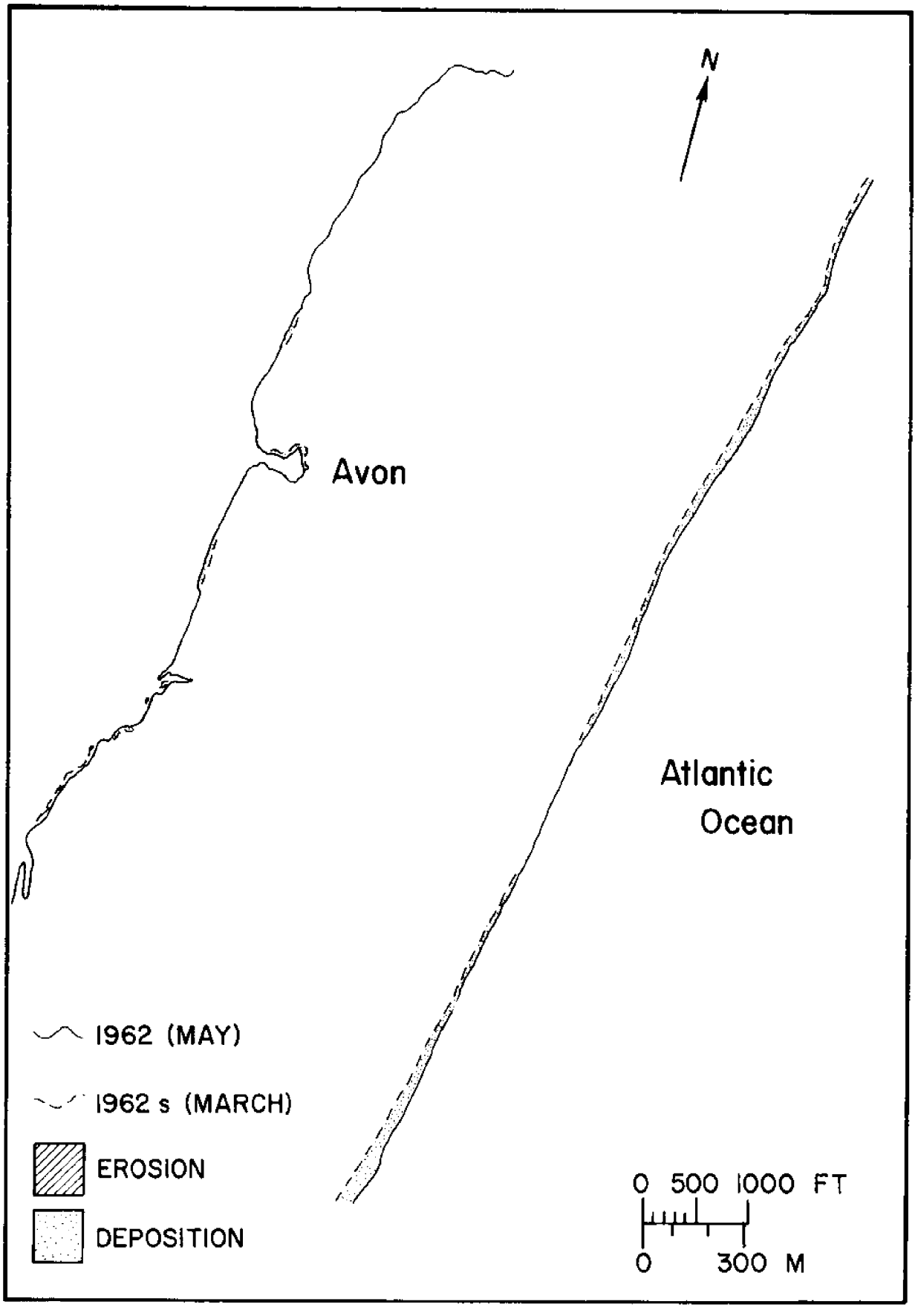


Fig. 37.—Shoreline changes at Locality 1[illegible] (Avon), March to May, 1962.

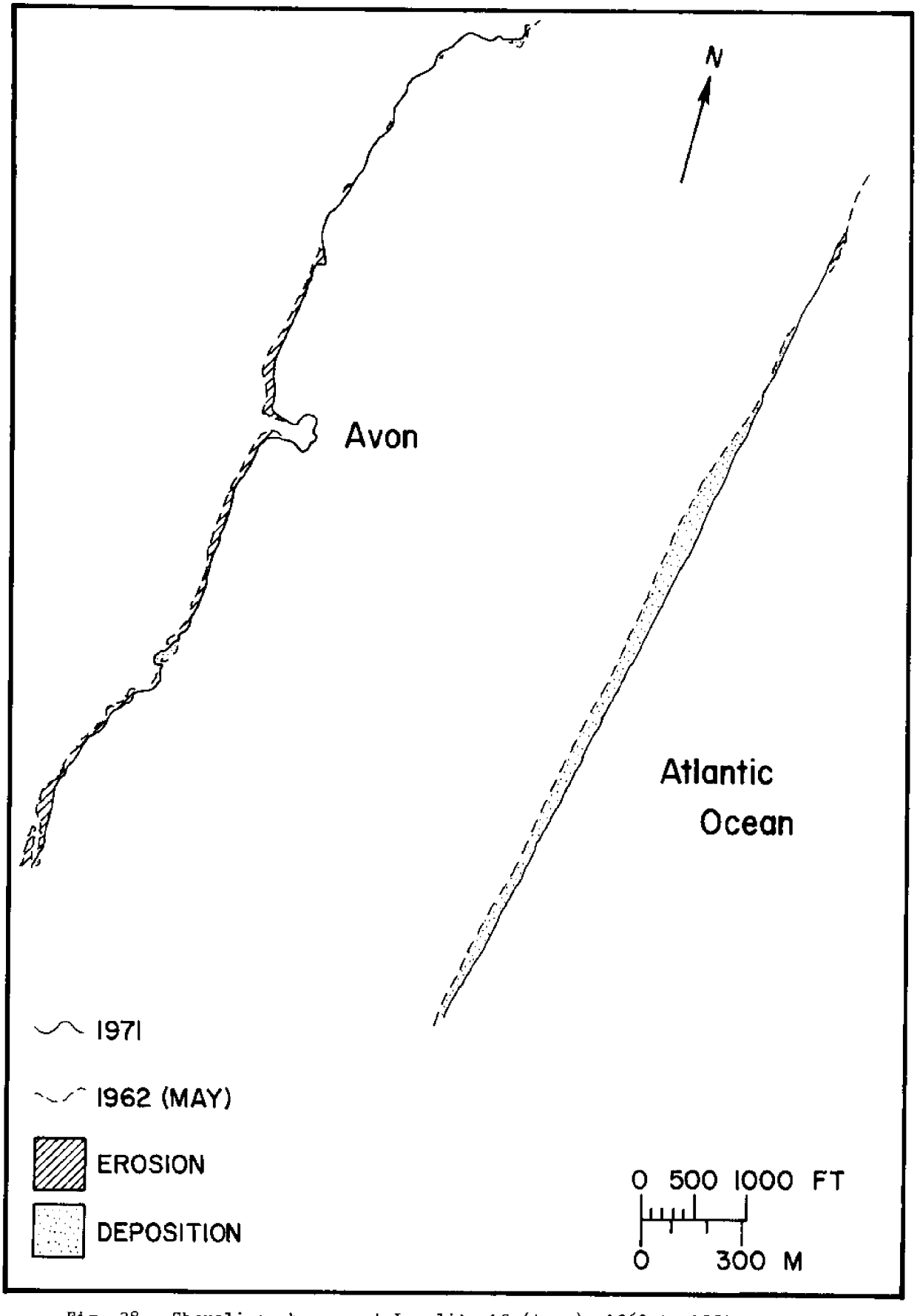


Fig. 38. Shoreline changes at Locality 13 (Avon), 1962 to 1971.

(less than 30 percent) between 1953 and 1971 (Fig. 39). Maximum local rates of erosion up to 2.5 feet per year are indicated. On the oceanward side of the barrier system, net deposition occurred over 85 percent of the shoreline with net erosion on no more than 15 percent at rates up to 5.5 feet per year between 1953 and 1971 (Fig. 39). A pattern similar to that for net effects between 1953 and 1971 is indicated for both sides of the barrier island between 1953 and 1955 (Fig. 40). The oceanward side of the barrier island underwent erosional changes between 1955 and 1962S (Fig. 41) which are likely related to the March 1962 storm. Erosion is shown along 95 percent of this shoreline between 1955 and 1962S. Figure 42 indicates possible depositional effects related to washover on the lagoonal side, and it illustrates smoothing of the oceanward shoreline by longshore currents after the storm activity. Progradation and repair of the oceanward shoreline is also shown by deposition along the shoreline between 1962 and 1971 (Fig. 43).

Locality 15 is positioned on Bodie Island immediately north of Oregon Inlet. On the lagoonal side, about 55 percent of the shoreline shows net erosion and 45 percent shows net deposition for the period 1962 to 1971 (Fig. 44). Maximum erosion rates range up to about 10 feet per year. On the oceanward side of L15, 85 percent of the shoreline shows net erosion and approximately 15 percent shows net deposition between 1962 and 1971 (Fig. 44). A maximum erosion rate ranging from 10 to 18 feet per year is indicated for this area of oceanward shore-

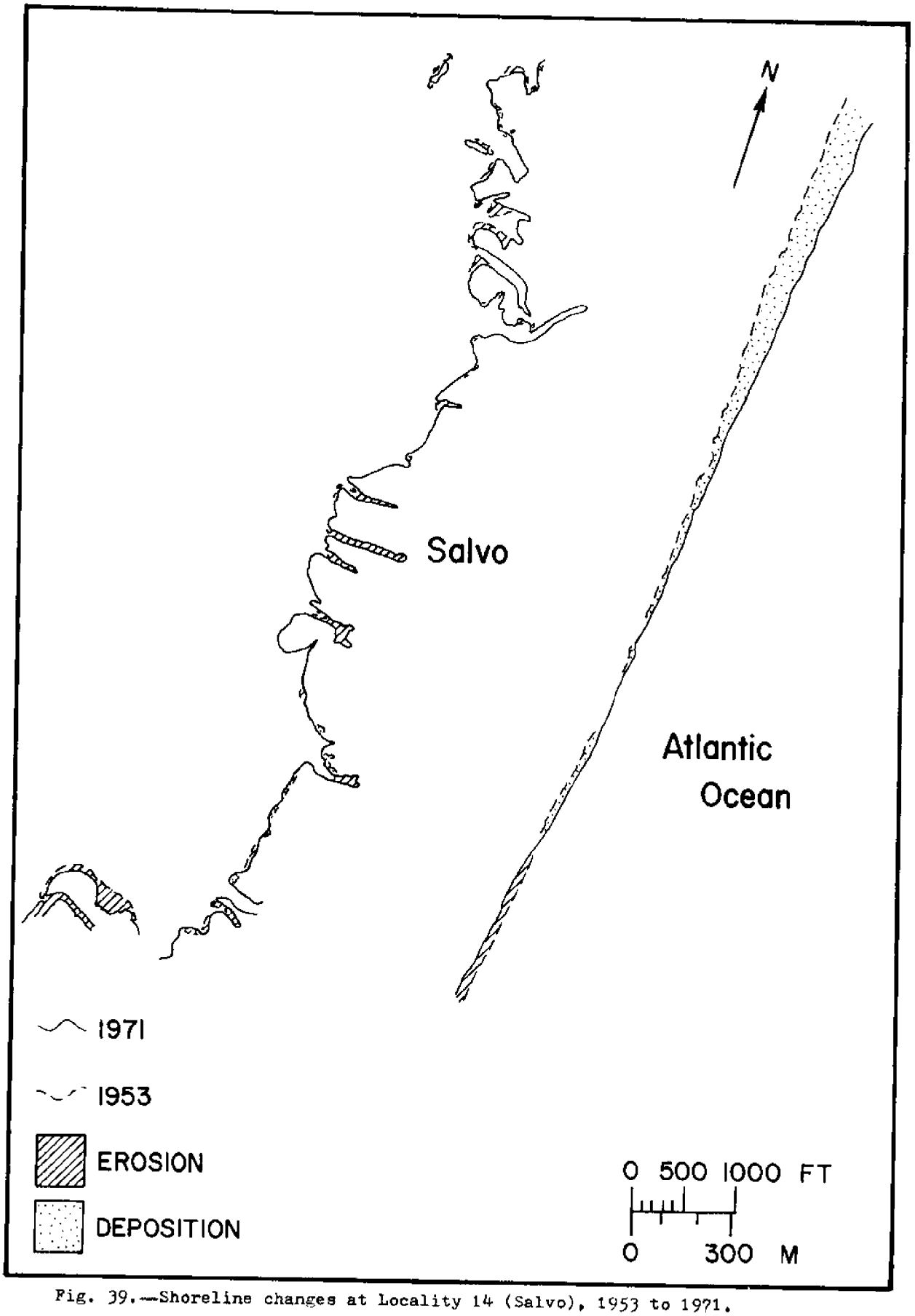


Fig. 39.—Shoreline changes at Locality 14 (Salvo), 1953 to 1971.

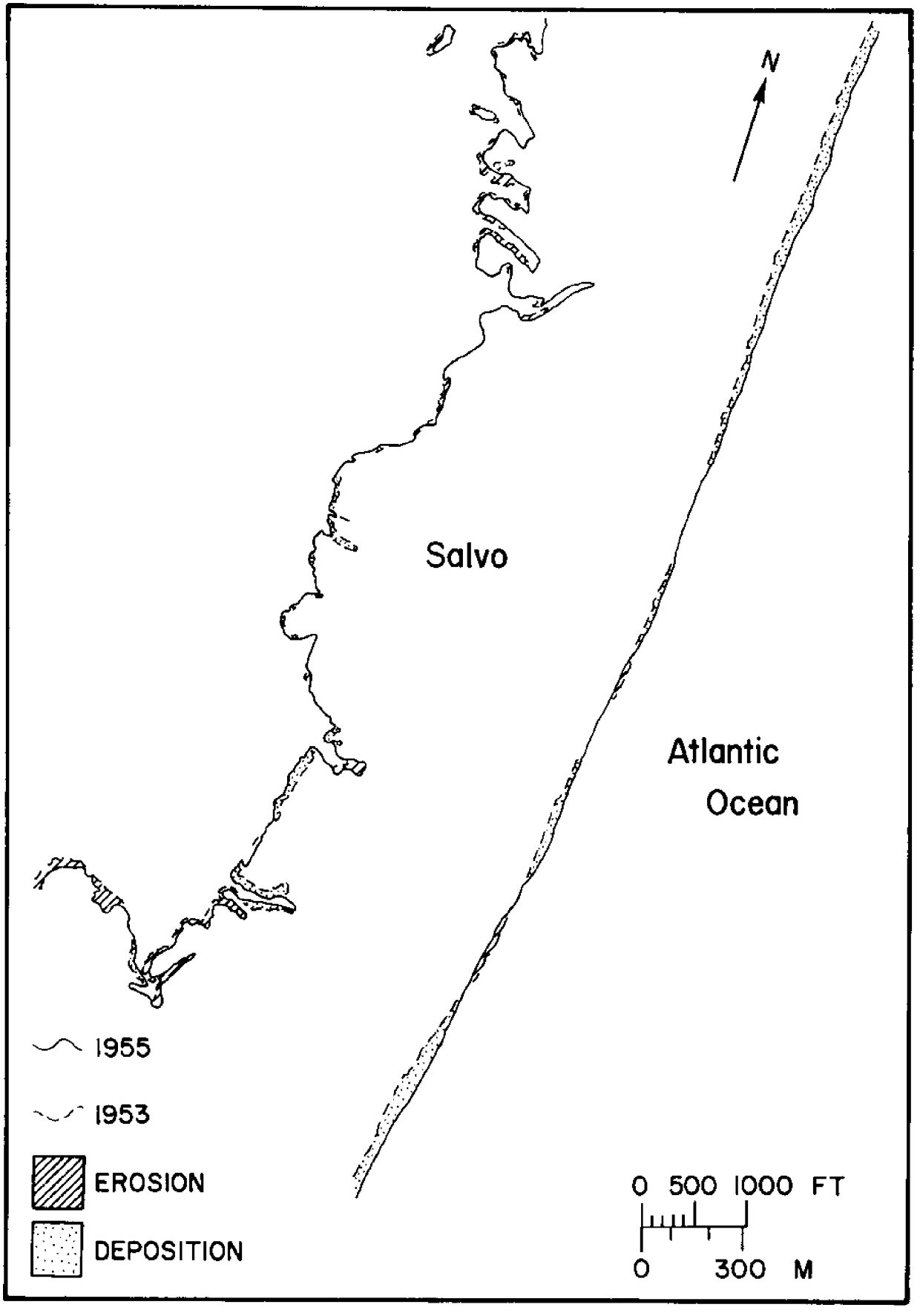


Fig. 40.—Shoreline changes at Locality 14 (Salvo), 1953 to 1955.

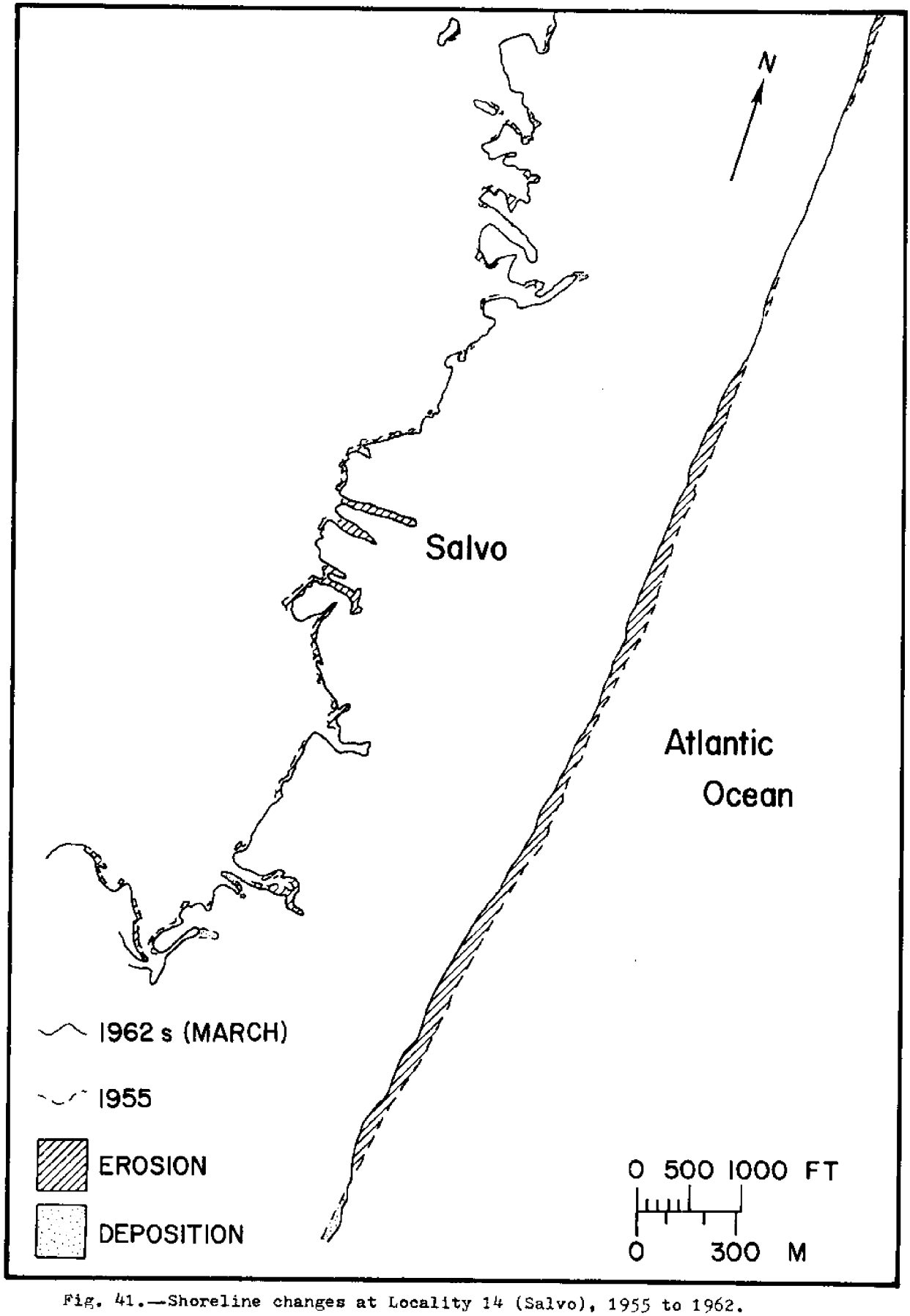


Fig. 41.—Shoreline changes at Locality 14 (Salvo), 1955 to 1962.

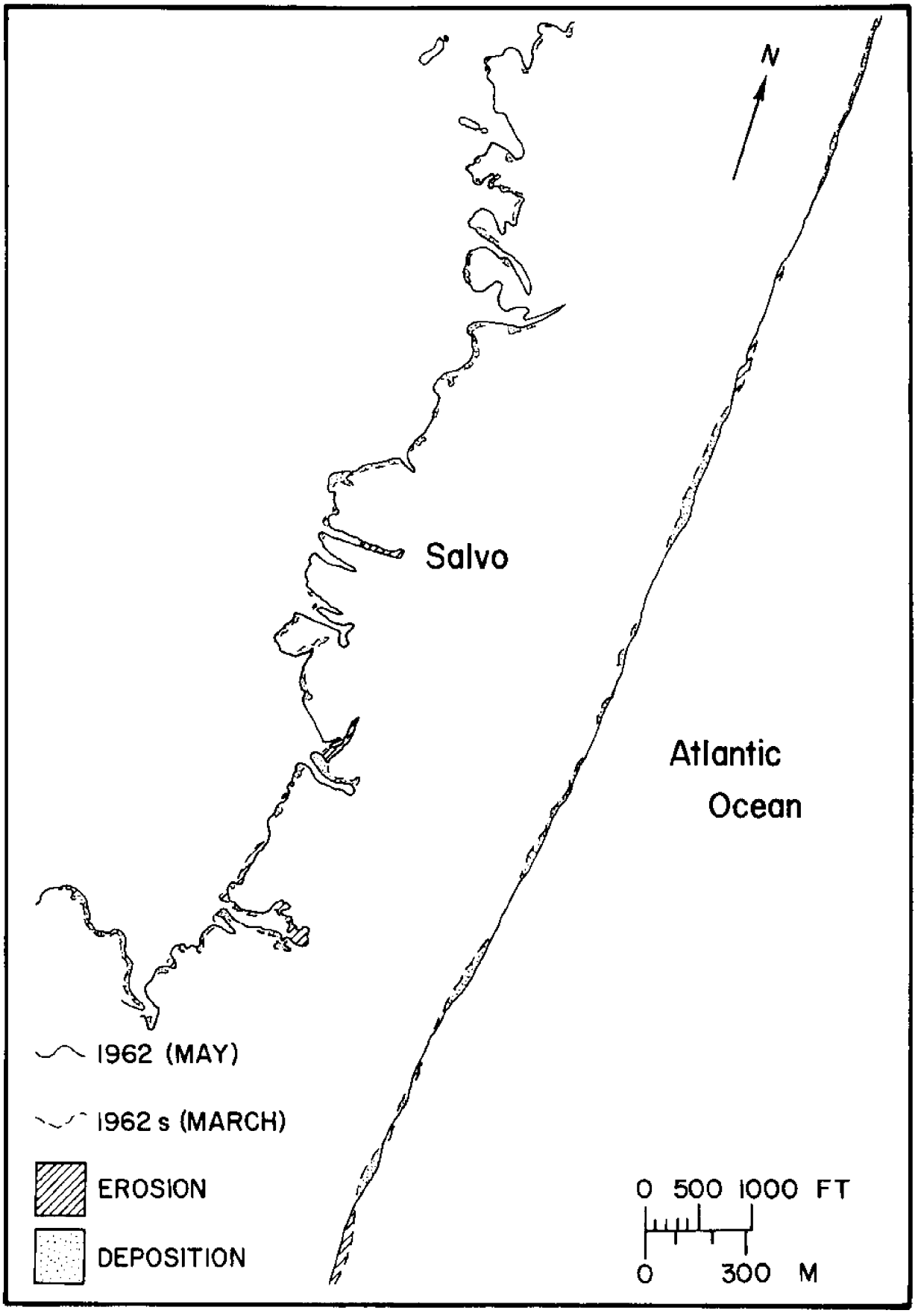


Fig. 42.—Shoreline changes at Locality 14 (Salvo), March to May, 1962.

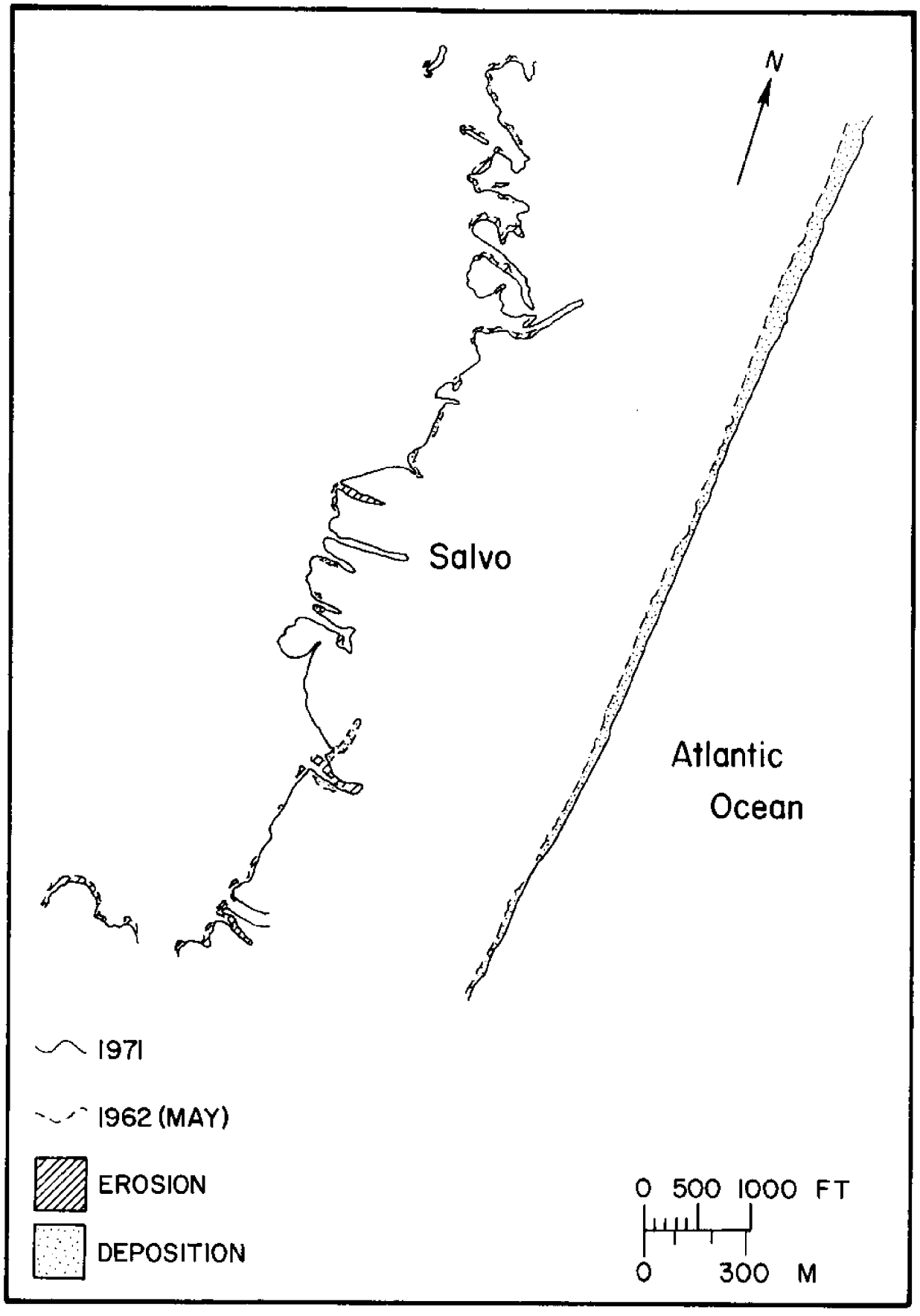


Fig. 43.—Shoreline changes at Locality 14 (Salvo), 1962 to 1971.

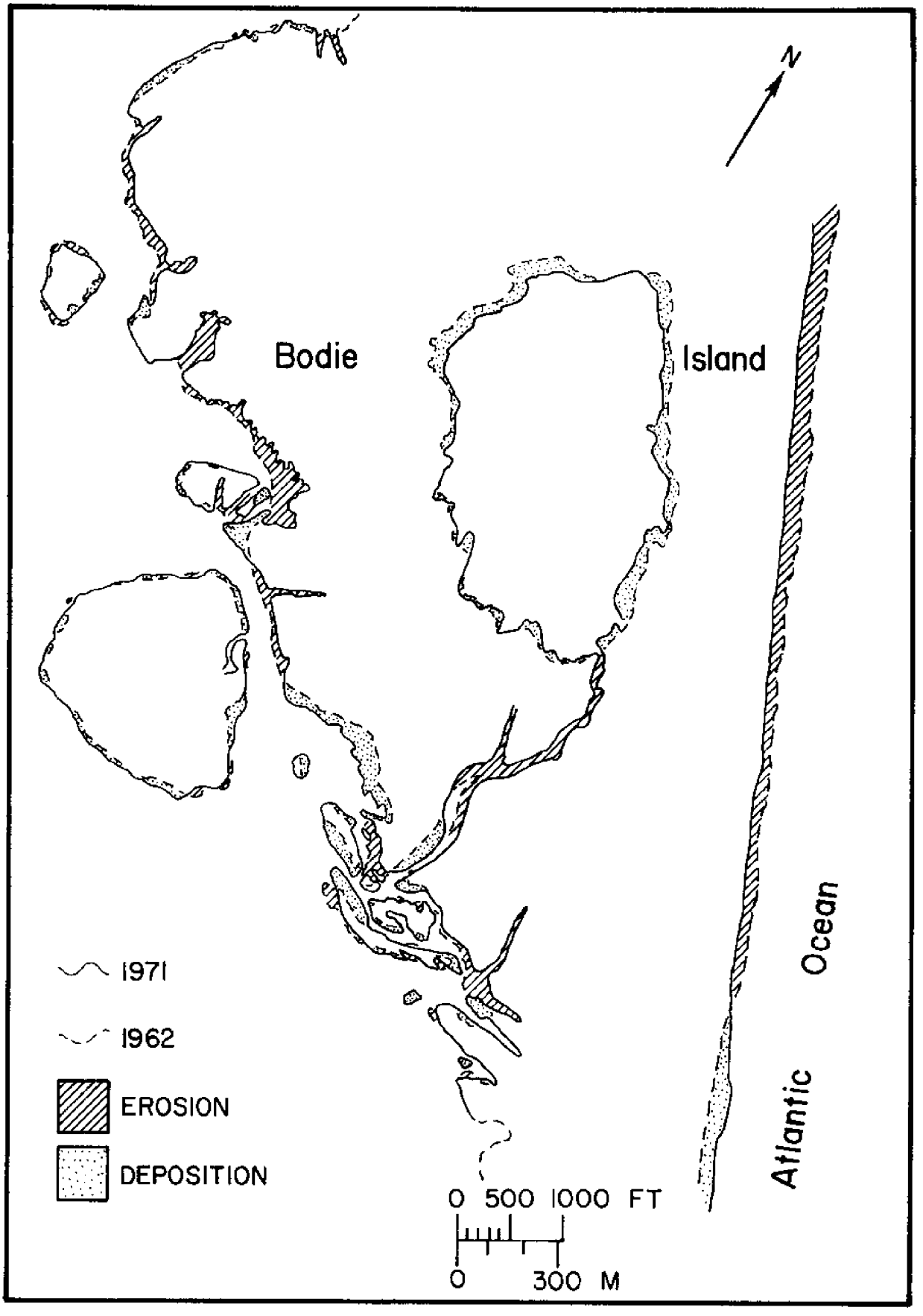
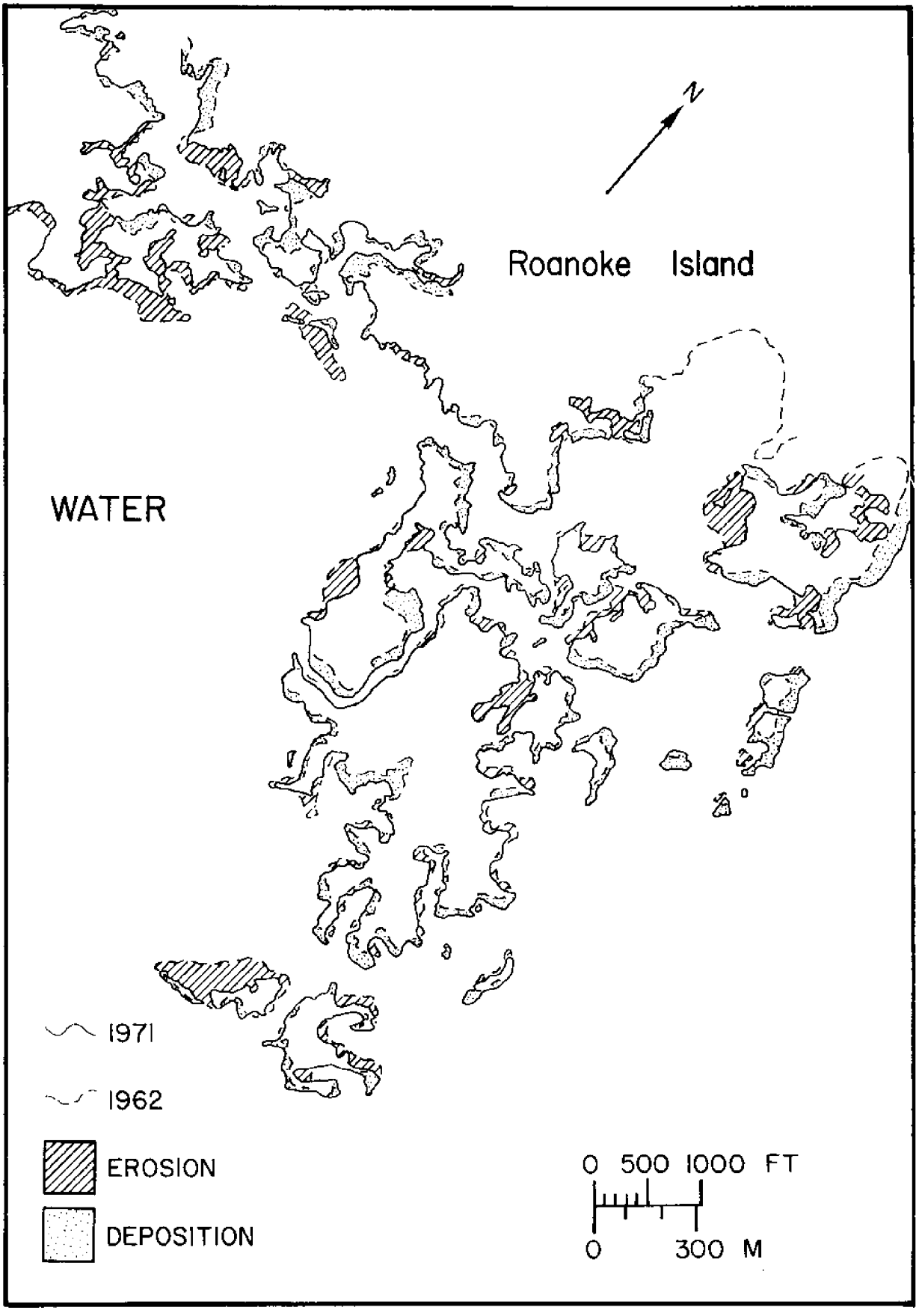


Fig. 44.—Shoreline changes at Locality 15 (Bodie Island), 1962 to 1971.

line.

C. Southern Tip of Roanoke Island

Locality 16 lies at the southern extremity of Roanoke Island. Between 1962 and 1971, net erosion and net deposition appear to have occurred in nearly equal percentages along the shoreline, and the non-static nature of this shoreline is shown by the areas of change in Figure 45. Erosion rates at this locality are difficult to estimate due to the irregular nature of the shoreline resulting from numerous small islands off the shore of Roanoke Island.



ig. 45.—Shoreline changes at locality 1 (Roanoke Island), 1962 to 1971.

SUMMARY AND CONCLUSIONS

Figures 46 and 47 summarize the data compiled in this study of (1) net percentages of shoreline which have been subjected to erosion or deposition and (2) generalized net maximum rates of erosion at the sixteen study localities. The data, which were derived from the analysis and interpretation of aerial photographs, provide important and characteristic patterns of shoreline changes as shown by the two summary figures.

The environment of highest energy occurs along the oceanward side of the barrier island system where storm-generated waves have the most profound effect on shoreline morphology. High percentages of erosion are characteristic of the oceanward side of the barrier (Fig. 46), and the highest erosion rates consistently occur in this position (Fig. 47). The data are in agreement with that derived by most studies which have concentrated on the oceanward side of the barrier island system. Locality 14 appears to be an exception to the general pattern of strong erosion and indicates local net deposition along the oceanward side of the barrier system.

The lagoonal side of the barrier island system is generally undergoing net erosion (Fig. 46). Locality 14 is an exception in that it is relatively stable since deposition slightly exceeds erosion.

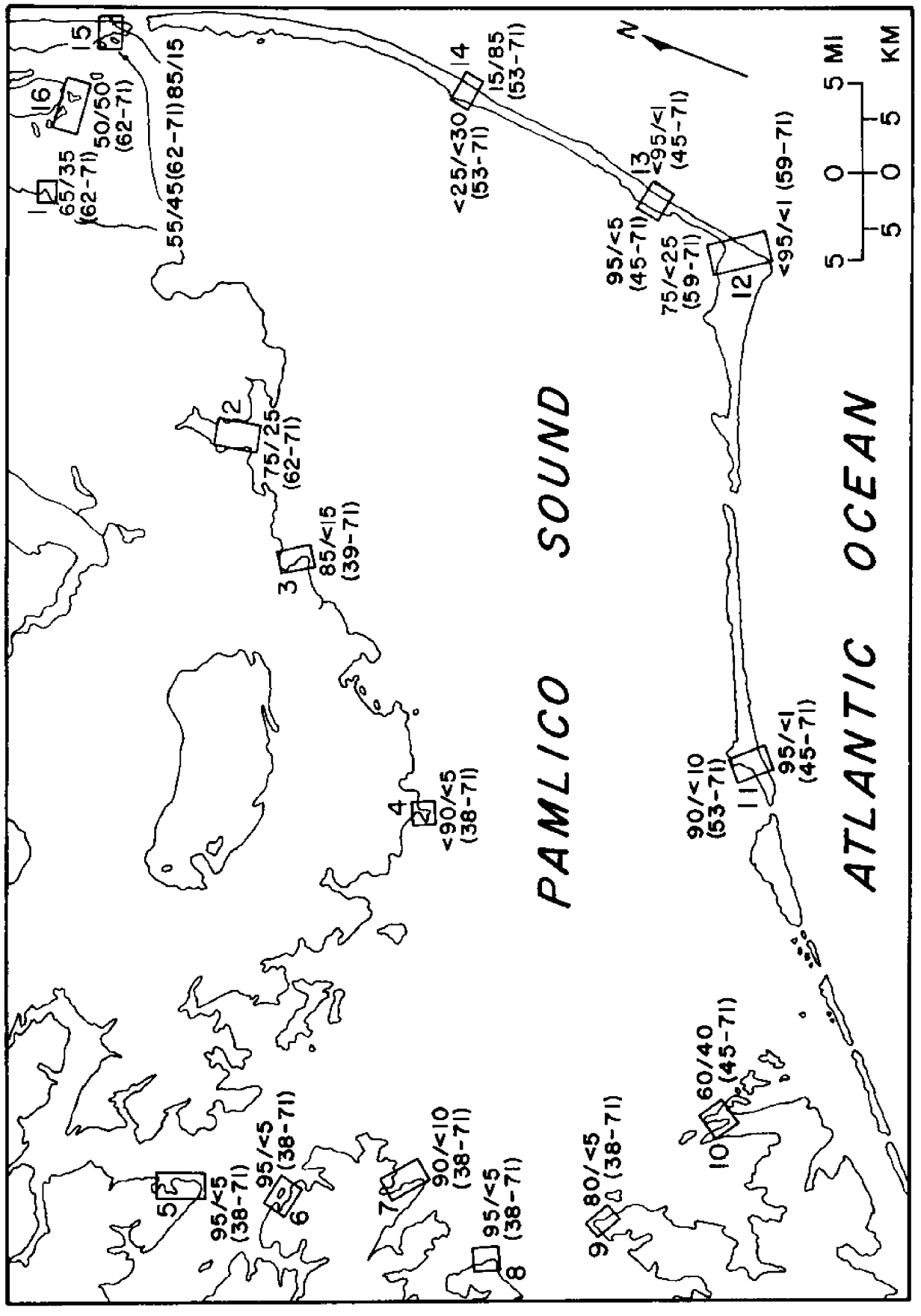


Fig. 46.—Percentage of shoreline undergoing erosion or deposition at the study sites.

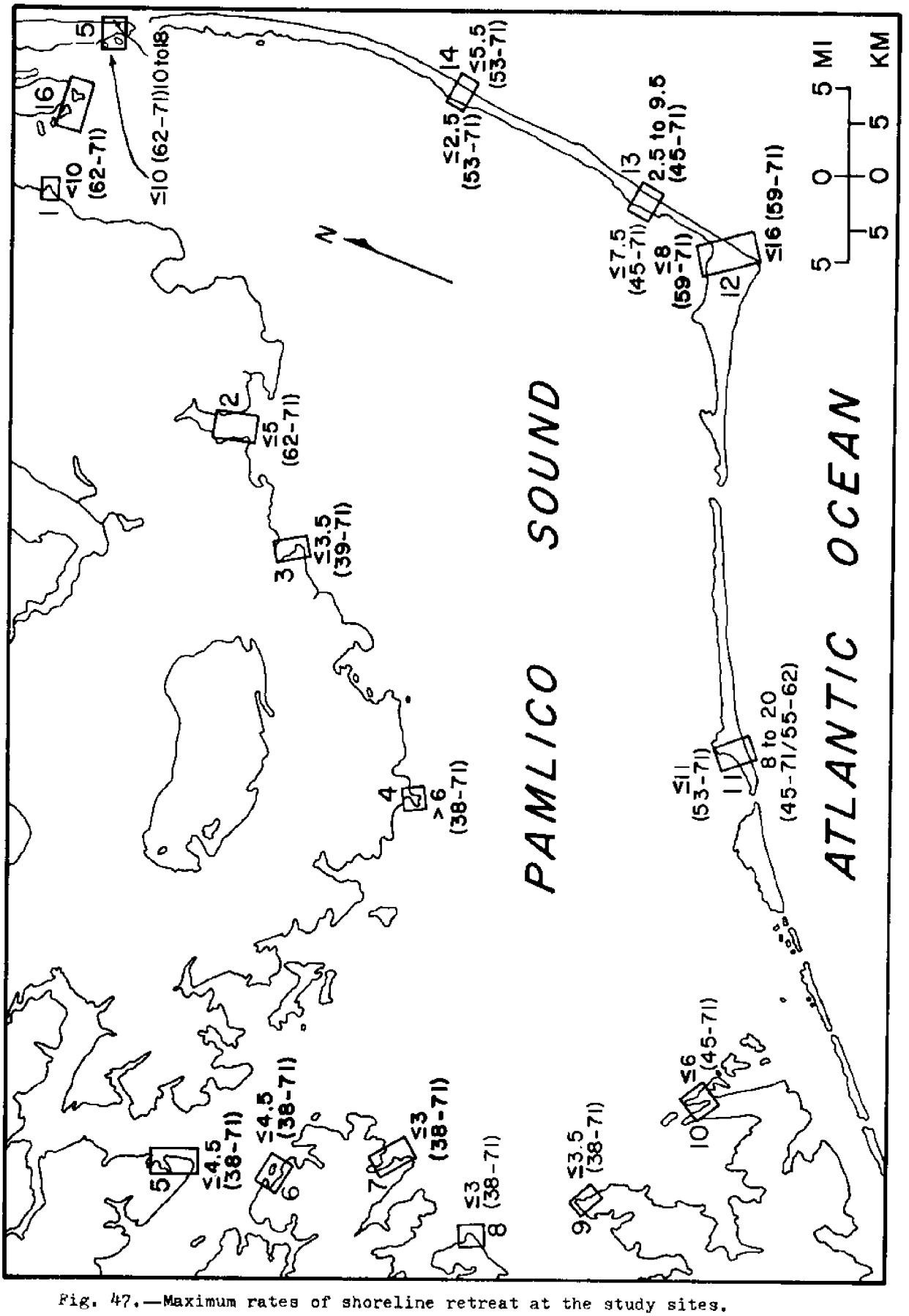


Fig. 47.—Maximum rates of shoreline retreat at the study sites.

At Locality 15, the lagoonal side shows less net erosion than was indicated for Localities 11 through 13. This may be because L15 is located at the northeastern end of Pamlico Sound where wind-generated waves and currents from the northeast would have less effect. The maximum erosion rate shown on Figure 47 for L15 may be high because few photographs were available to obtain a reliable mean value. However, Figure 47 generally indicates maximum erosion rates somewhat lower than those for the oceanward side of the barrier island system and higher than the rates shown for most of the mainland marsh side of the sound.

The effects of storm activity are well demonstrated by the 1962S and 1962 shorelines along the barrier island system at Localities 11, 13, and 14. Evidence exists for washover of sediment into the lagoon after severe storms, and these washover fans tend to be eroded under non-storm conditions. Prograding and repair of the oceanward shoreline by longshore currents is apparent soon after storm activity.

The mainland side of the sound experiences considerable net erosion at every locality except L1 and L10 (Fig. 46). As with Localities 15 and 16, L1 occurs at the northeastern end of the sound where waves and currents from the northeast have the least erosional effect. The maximum erosion rates shown for L1 (Fig. 47) may be slightly high because few photographs were available for comparison to obtain

a meaningful average value. Nevertheless, L1 is situated at a headland where erosional activity would be greatest. Locality 10 is supplied with sand via the inlet in the barrier island system southeast of the locality, and net deposition is locally high because of the ferry terminal break-water which has blocked the sediment supply line and produced an area of strong deposition on the upcurrent side of the breakwater.

Localities 2 through 9 (mainland) experience net erosion at maximum rates which are typically less than either the oceanward or lagoonal sides of the barrier island system (Fig. 47). However, the data does suggest that the salt marsh shoreline along the mainland side of Pamlico Sound is activity receding as a result of erosion.

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Discussions with Michael Katuna and Edward Custer aided in the development of the report. Gerald Baum drafted the illustrations.

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