SHORE RECESSION IN SOUTHEASTERN WISCONSIN

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During April, 1929, frequent mention has been made in the daily press of the high water conditions in several of the Great Lakes. On April 12, 1929, Chicago Sanitary District engineers found the level of Lake Michigan 582.34 feet A. T. This is 3.42 feet higher than the average level in 1927, which was reported as 578.96 feet A. T. The higher water, alone, probably would attract but little attention, but the frequent severe storms during the present spring have caused exceptionally heavy wave action on the shores of Lake Michigan and of others of the Great Lakes. Damages amounting to more than $1,000,000 in a single storm were reported from Chicago and vicinity. The entire sweep of the west shore of Lake Michigan and the south shore of Lake Erie have been affected especially by the repeated storms. The obvious results of this erosion are evident in fresh slumps, fallen trees, and wave-swept beaches visible in many places along the Lake Michigan shore. That considerable material has been shifted in these storms is indicated in the newspaper statement that in Evanston, Illinois, 40,000 tons of sand, dumped near the lake and to be used in construction work, were entirely removed in the storm of April 2, 1929. Similar changes during storms have been reported for earlier dates from Kenosha, Wisconsin.

With wide-spread attention thus directed to the wasteful work of the waves, this seems an opportune time to present certain quantitative results of the energy expended. The purpose of this report is to bring into one summarization the data on this subject that have been accumulating for more than 60 years. Some additional measurements have been recorded since reference to this erosion was last published in 1920.[1] Valuable data have been contributed by Mr. W. E. O'Brien, City Manager of Kenosha, Wisconsin.

The western shore of Lake Michigan, in the southern part of the basin, is composed of three general types of material: glacial

[1] Ball, J. R., "The Intercision of Pike River, near Kenosha, Wisconsin," Trans. Ill. Acad. Sci., Vol. XIII, 1920, pp. 323-326.

till or boulder clay, stratified clays and sands of lacustrine origin, and bedrock. A fourth material is eolian sand, but it forms the shore at but few places where recession is occurring. In the area under consideration, bedrock forms the shore at only one known place—Wind Point, four miles north of Racine. The greatest resistance to erosion is possessed by the bedrock that forms at Wind Point a projecting salient. The least resistance to erosion is offered by the lacustrine deposits, especially where the shores are low. High cliffs of hard till or boulder clay are eroded with greater difficulty.

The results of wave erosion have been: first, the cutting away of the ancient lacustrine plain of the higher lake stages along 69 of the 153 miles of coastline from Evanston, Ill., to Manitowoc, Wis.; and second, the general development throughout most of this distance of a high cliff and wave-cut platform.

The shore recession in the southern Lake Michigan basin was noted as early as 1864 by Charles Whittlesey,[2] and very soon after that by Henry M. Bannister. Whittlesey compared the rate of wave erosion in clay and sand deposits at Milwaukee with that in similar deposits at Cleveland, where he calculated the average annual recession to be 5.54 feet. Whittlesey further observed that wave erosion is least effective in the low lake stages, when beaches are broad and protect the cliffs behind them.

Bannister in 1868 made the following statement concerning the ancient beach ridges of that part of the Chicago plain on which northern Evanston and Wilmette are situated:[3] "The ridges which are cut off by the lake strike the shore at a small angle, and from their direction we are able to judge the trend of the coast in former times, and it appears that a large territory, probably many square miles in extent, has been washed away by the wearing action of the lake waves. At the present rate of wear, which at the greatest estimate, and at the most exposed points, is but a few feet annually, it must have taken many hundreds and even thousands of years to wear away this territory, the lake being at or very near its present level." Two years later Bannister[4] called attention to the wave erosion just south of Waukegan, Illinois, where the bluff, unprotected in some places by a beach, was being rapidly under-

[2] Whittlesey, Charles, "Fresh-Water Glacial Drift of the Northwestern States," Smithsonian Contribution 197, 1864, p. 27.
[3] Bannister, Henry M., "Geology of Cook County," Ill. Geol. Surv., Vol. III, 1868, p. 242.
[4] Bannister, Henry M., "Geology of McHenry and Lake Counties," Ill. Geol. Surv., Vol. IV, 1870, p. 127.

mined and carried away. The actual rate of erosion Bannister did not determine, but he judged "that in the course of years it might be considerable, amounting perhaps to several hundred feet in a century."

The first comprehensive quantitative measurement on the rate of shore recession in this region were compiled and published by Andrews[5] in 1870. Chamberlain[6] in 1877 published the results of measurements made respectively by Dr. P. R. Hoy, S. G. Knight,

TABLE I—EARLIER DATA ON SHORELINE RECESSION.

Observer	Period	Locality	Total observed recession	Average annual recession
Andrews	15 to 35 years preceding 1870	23 points between Evanston and and Manitowoc		5.28 ft.
Hoy	1840-1884	Racine cemetery	6.82 acres along 921 feet of shore	9.73 ft.
Knight	1836-1874	18 section and quarter-section lines in Racine County	126.72 ft. (mean)	3.33 ft.
Chamberlin	1835-1874	8 section lines in in Milwaukee County	103.80 ft. (average)	2.77 ft. (mean)
Galvin	41 to 57 years following 1928	8 points in Berrien County, Mich.	152.36 ft. (average)	3.30 ft. (mean)

and himself. In 1899 Leverett[7] published the results of measurements made by Mr. Glavin, at one time Surveyor of Berrien County, Michigan. Table I is a summary of the results of the five men mentioned.

The measurements in Table I are all taken over periods of time sufficiently long to include both high and low lake stages and, therefore, times of both rapid and slow wave erosion. At times of high water level, erosion is surprisingly rapid, as shown by certain measurements made in 1905 to 1907 at Manitowoc by

[5] Andrews, Edmund, "The North American Lakes Considered as Chronometers of Post-Glacial Time," Trans. Chicago Acad. Sci., Vol. II, 1870, pp. 1-24.

[6] Chamberlin, T. C., "Geology of Wisconsin," Vol. II, 1877, pp. 219-233.

[7] Leverett, Frank, "The Illinois Glacial Lobe," U. S. G. S. Mon. XXXVIII, 1899, p. 458.

Goldthwait.[8] Here a low cliff in soft lacustrine deposits was pushed back at a rate of more than 40 feet per year during the period mentioned. For that interval the mean level of Lake Michigan was between 581 and 582 feet.

Since the publication of the figures set forth above, certain measurements have been made in the vicinity of Kenosha, Wisconsin, by Mr. W. E. O'Brien and the senior author of this paper. Mr. O'Brien, in 1922, had occasion to resurvey certain section and quarter-section lines that intercept the line of the Great Lakes Survey in 1835. The results of his work are set forth in Table II.

TABLE II—MEASUREMENTS BY W. E. O'BRIEN IN TWP. 1 NORTH, RANGE 23 EAST (SOUTH OF KENOSHA).

Location	Total recession, 1835-1922	Average Annual recession
N. line Sec. 32	655 ft.	7.64 ft.
Quarter-section line, Sec. 29	670 ft.	7.70 ft.
N. Line Sec. 29	552 ft.	6.33 ft.
Quarter section line, Sec. 20	675 ft.	7.76 ft.
N. line Sec. 20	480 ft.	5.52 ft.
Quarter-section line, Sec. 17	529 ft.	6.08 ft.
Average	595 ft.	6.84 ft.

Along this stretch of 2½ miles, the loss in acres for the period mentioned was 180.29.

In 1918 the senior author established north of Kenosha several lines which he remeasured in 1921 and again in 1929. During this period most of his original markers (the "trees" mentioned below) were lost in the rapid recession of the shore. Tables III and IV give his records of cliff recession as indicated by those markers which still remain.

The striking contrast between the rate of recession indicated in Table III and that in Table IV is explained by the lake levels at these two periods. In 1917 and 1918 the level of Lake Michigan exceeded 582 feet[9]; in 1919 and 1920 it exceeded 581 feet. The drop in elevation continued until 1927, when the mean level was less than 579 feet. During 1928 and 1929 the lake again has risen

[8] Goldthwait, James W., "Abandoned Shorelines of Eastern Wisconsin," Wis. Geol. and Nat. Hist. Surv., Bull. 17, 1907, p. 58.

[9] Henry, Philip W., "The Great Lakes-St. Lawrence Waterway," Geog. Review, Vol. XVII, 1927, pp. 258-277.

to a level of more than 581 feet, and the waves now are strongly attacking the cliff at the several points mentioned in Tables III and IV. It appears, therefore, that any trustworthy figures on the average rate of shore recession must cover a period of time sufficiently long to cover both high and low lake stages.

TABLE III—MEASUREMENTS IN TWP. 2 NORTH, RANGE 23 EAST, NORTH OF KENOSHA, FOR THE PERIOD 1918-1921.

Station	Location	Total recession	Annual recession
Tree 1	S. line Sec. 19	29 ft.	9.67 ft.
Tree 2	3 rods N. of Tree 1	33 ft.	11.00 ft.
Tree 3	N. line SE¼ of SE¼ Sec. 19	41 ft.	13.67 ft.
Tree 4	35 rods N. of Tree 3	45 ft.	15.00 ft.
	Average	37 ft.	12.33 ft.

TABLE IV—MEASUREMENTS IN THE SAME LOCALITY, FOR THE PERIOD 1921-1929.

Station	Location	Total recession	Annual recession
Tree 2	See Table III	3.2 ft.	0.4 ft.
Tree 4	See Table III	8.5 ft.	1.06 ft.
	Average	5.85 ft.	0.73 ft.

Interest in the shore recession naturally centers about two topics: the actual loss of property and the physiographic changes. If the average recession, before breakwaters or "groins" were built to retard it, was 3.5 feet per year between Evanston and Manitowoc, the land destroyed must have amounted to 64.9 acres per year, or more than ten square miles per century. Further, if in a year of exceptionally rapid erosion a recession of 12.33 feet should occur between Kenosha and Racine, the land destroyed would amount to 15 acres. If this land is worth $1,000 an acre the property loss would amount, therefore, to $15,000 in a year along a section of coast only ten miles in length.

The physiographic development of most interest has been the peculiar modification of drainage known as "intercision."[10] Pike

[10] Goldthwait, James W., "Intercision, a Peculiar Modification of Drainage," Sch. Sci. Math., 1908, pp. 129-139.

River at Kenosha furnishes an admirable example of this process. This stream, entering the ancient lacustrine plain about five miles north of Kenosha, bends directly south and flows in a broad, somewhat winding valley almost to Kenosha before entering the lake. It is clear that any recession of the lake cliff must inevitably lead to the interception of the Pike River valley where its curves approach the lake, with a consequent shortening of the stream itself. Such interception actually has occurred twice. A part of the harbor at Kenosha is a curved lagoon situated in a rather narrow valley, open at both ends to the lake, and directly south of Pike River and within its projected course. This lagoon is clearly a severed part of the Pike River valley, and was recognized as such as early as 1847 by Lapham.[11] Previous to 1924 the mouth of Pike River was in the NE¼ of Sec. 30, T. 2 N., R. 23 E. In 1924 or 1925 a breach was opened by wave action at a curve in the valley one-half mile farther north. For a time the river possessed two outlets, and these even alternated as first one and then the other was closed by wave deposition. At present, however, the former mouth seems to have been permanently closed by the building of the beach ridge, and the old channel lying south of the present river mouth has become a stagnant lagoon.

At many places in the Great Lakes region the conditions have been favorable for intercision. The combination of winding stream valleys parallel to the lake shore and rapid shore recession has resulted in intercision during both ancient and present lake stages. Intercision at one of the higher lake stages has occurred just north of Waukegan,[12] Illinois, and also in northern Ozaukee County, Wisconsin.[13] Intercision is impending in the present course of Sucker Creek, Ozaukee County, Wisconsin, and at another curve in the Pike River valley one-half mile north of its present mouth. In the instance first mentioned, the authors in March, 1929, measured the distance across the upland between the top of the lake cliff and the top of the cut bank in the river valley and found it to be twelve feet, one inch. The distance between the two water bodies at lake level, however, is much greater on account of the slump both in the lake cliff and in the valley wall. Probable cases of in-

[11] Lapham, I. A., "On the Existence of Certain Lacustrine Deposits in the Vicinity of the Great Lakes," Am. Jour. Sci., 2nd Ser., Vol. III, 1847, pp. 90-94.

[12] Atwood, W. W. and Goldthwait, J. W., "Physical Geography of the Evanston-Waukegan Region," Ill. Geol. Surv. Bull. 7, 1908, pp. 83-84.

[13] Goldthwait, J. W., "Intercision, a Peculiar Kind of Modification of Drainage," Sch. Sci. Math., reprint, 1908, p. 2.

tercision may be seen on maps of the Mentor, Ohio, Quadrangle, and also the Cleveland, Ohio, Quadrangle. In the case of the latter, Whittlesey's map on page 26 of his report on the "Freshwater Glacial Drift of the Northwestern States" (cited above) strengthens the suggestion of intercision exceedingly.

Two conclusions may be drawn from this study of shore recession: first, the recession is rapid and wasteful where it is not checked by breakwaters or "groins," or by a temporary beach of the lake's own making; and, second, the rate of recession is not uniform but variable, being surprisingly rapid at times of high lake level, and very slow at times when the lake waters are low.