

CHAPTER 7

SOME CHARACTERISTICS OF BOTTOM SEDIMENTS ALONG THE ILLINOIS SHORE LINE OF LAKE MICHIGAN

R. O. Fisher

State of Illinois, Division of Waterways
Springfield, Illinois

The State of Illinois is engaged in a long range study of shore erosion phenomena along the Illinois shore of Lake Michigan in order to obtain more definite information on the numerous engineering, geologic and meteorologic factors involved in the erosion process.

One phase of this study is devoted to the characteristics of the bottom sediments of the lake based upon samples taken annually along certain selected range lines. These range lines were first established for the 1946 cooperative study with the Beach Erosion Board, Corps of Engineers and were used that year by the Corps and again in 1950, 1951, 1952 and 1953 by the Division of Waterways. The ranges are spaced approximately one mile apart commencing at the Wisconsin-Illinois State line and extending southward through Chicago to the Indiana-Illinois line. At the present time, the sampling program is confined to that reach of the lake from the Wisconsin line to the northern limits of Chicago. (Fig. 1.) Each range line azimuth was established at approximately 90° to the general shore line at that locality.

Approximately 22 lake bottom samples are taken each year on each range. An attempt has been made to obtain a sample at each 2 ft. change in depth from the shore line to about the 15 ft. depth, and then at each 3 ft. to 5 ft. depth change thereafter to a depth of 60 feet, or three miles distance from shore, depending on which is reached first.

The samples are taken from an amphibian truck and the course of the truck and the location of each sample is controlled by two beach parties operating transits for fix angles, etc. Communications during the sampling are maintained by two-way radio operations between the truck and the beach crews. The samples thus secured are surface samples and are taken with a drag-type sampler based upon recommendations of the Beach Erosion Board, (Figs. 2 and 3). The sampler consists essentially of a short section of pipe equipped with a cutting lip, a pipe cap for emptying and a bail for attaching the cable. Stability while in motion through the water was considerably improved by the addition of a vertical fin to the top of the sampler. Very satisfactory results have been obtained in sand bottoms, but considerable difficulty has been experienced in beds of large gravel and on clay or fill bottoms. A drop-type sampler has been used to a limited extent in clay and fill areas with some degree of success.

Beach samples are collected on the shore end of each of the ranges. In general, samples are taken at the water's edge, the toe of the bluffs and at a point between.

Laboratory work on samples has included the following:

1. Sieve analysis, using the $\sqrt{2}$ series sieves throughout the

COASTAL ENGINEERING

range down through the No. 325 mesh.

2. Separation of light and heavy minerals, using bromoform.
3. Magnetic mineral separation, using a weak magnet.
4. Carbonate separation, using diluted hydrochloric acid.

The analysis for heavy minerals, magnetic minerals and carbonates was made in the hope that movement of the sediments might be traced. However, no unusual concentrations were found which could be attributed to any one source material. The glaciation which occurred over this area with the resultant extremes of water depths during those periods, has evidently so sorted the bluff, beach and bottom material that the presence in various amounts of heavy minerals, magnetic minerals or carbonates gives no apparent indication of sediment movement or littoral drift. Therefore, in 1952 the magnetic and carbonate analyses were discontinued, although portions of each sample have been prepared and sorted should these analyses ever need to be resumed.

The results of the grain size analysis of each sample are plotted in the form of a cumulative curve from which the median and quartile diameters and other descriptive parameters may be obtained.

With the thought in mind that a definite pattern of sediment size distribution might be present along the Illinois shore line, plan sheets for each year's survey have been prepared upon which are plotted the location and median diameter of each offshore sample. There were then drafted thereon lines of equal median diameter, much in the same manner as the drafting of contour lines on a topographic map. It is recognized that this is not a precise method in view of the relatively small number of samples and the wide spacing of the ranges, but it is felt that such a procedure does serve to present a general pattern of the size distribution of the material on the lake bottom. Fig. 4 is the plot of the median diameters from the Wisconsin State line to Waukegan for the 1950 and 1952 surveys. This area is in the Northern Lake Plain section, is subject to marked erosion at the north, and due to the presence of Waukegan Harbor and the breakwater at Northern Illinois Public Service Company, is accreting at the south. For simplicity, the size distributions have been broken into three groups: (1) Sizes up to 0.25 mm median diameter, called fine sand or under; (2) Sizes from 0.25 to 1.00 mm designated as medium sand, and (3) Sizes above 1.00 labelled as gravel or above. As can be seen, the 1950 and 1952 plots show a marked similarity and this same similarity was also present for the 1946 survey.

This reach of the shore is practically in its original state with few man-made structures present except at Waukegan. Fig. 5 shows a further breakdown of the median diameters in the inshore area into medium sand (0.25 mm or above), fine sand (.25 mm to .10 mm), and very fine sands or under (.10 mm or below). There is a narrow band of fine sand (.25 to .10 mm median diameter) present along the immediate shore line, outside of which very fine sand is present out to about the 60 ft. depth. Using P.D. Trask's formula for sorting coefficient to indicate the slope of the mechanical analysis curve of each sample, the fine sands and very

SOME CHARACTERISTICS OF BOTTOM SEDIMENTS ALONG THE ILLINOIS SHORE LINE OF LAKE MICHIGAN

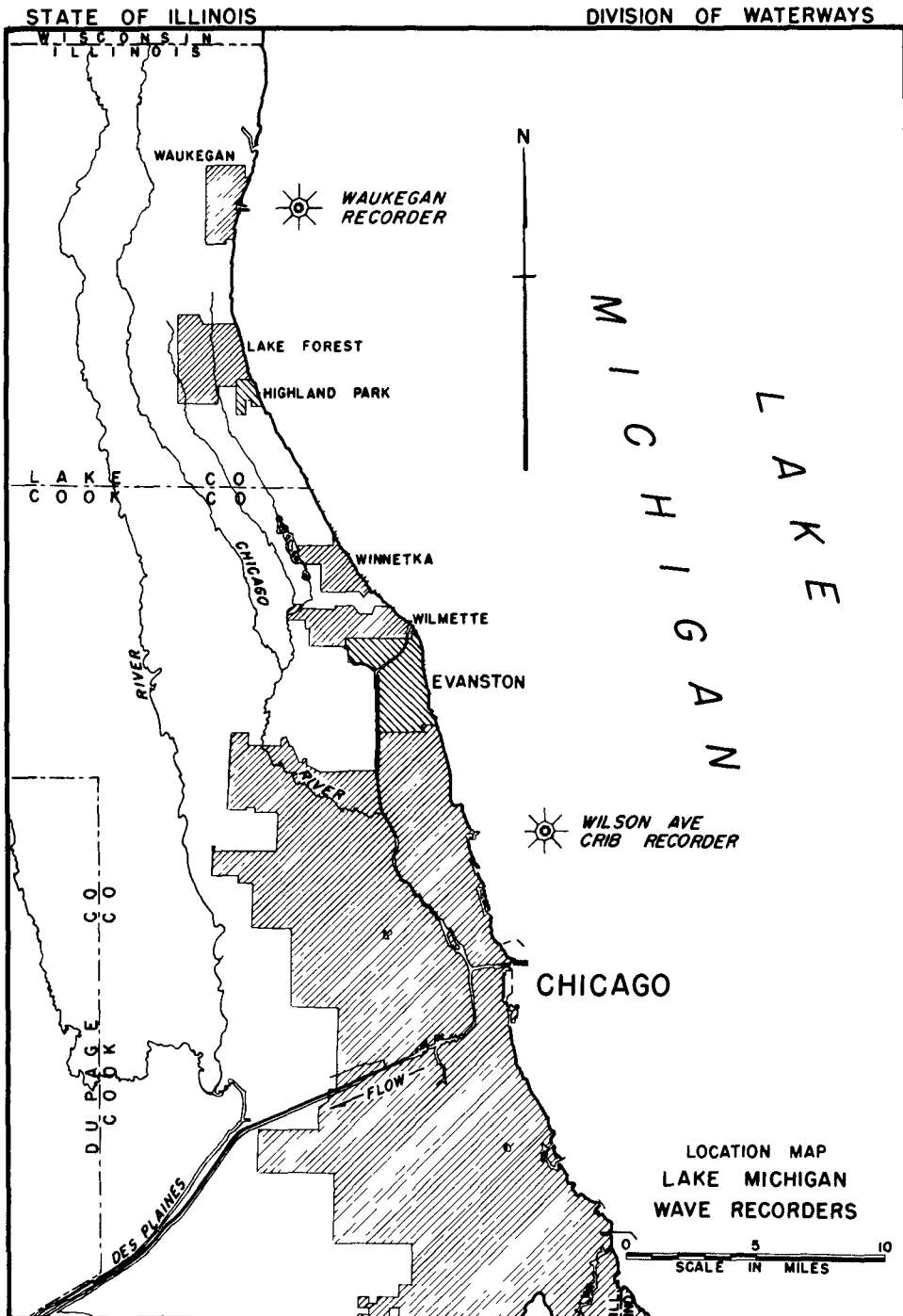


Fig. 1.

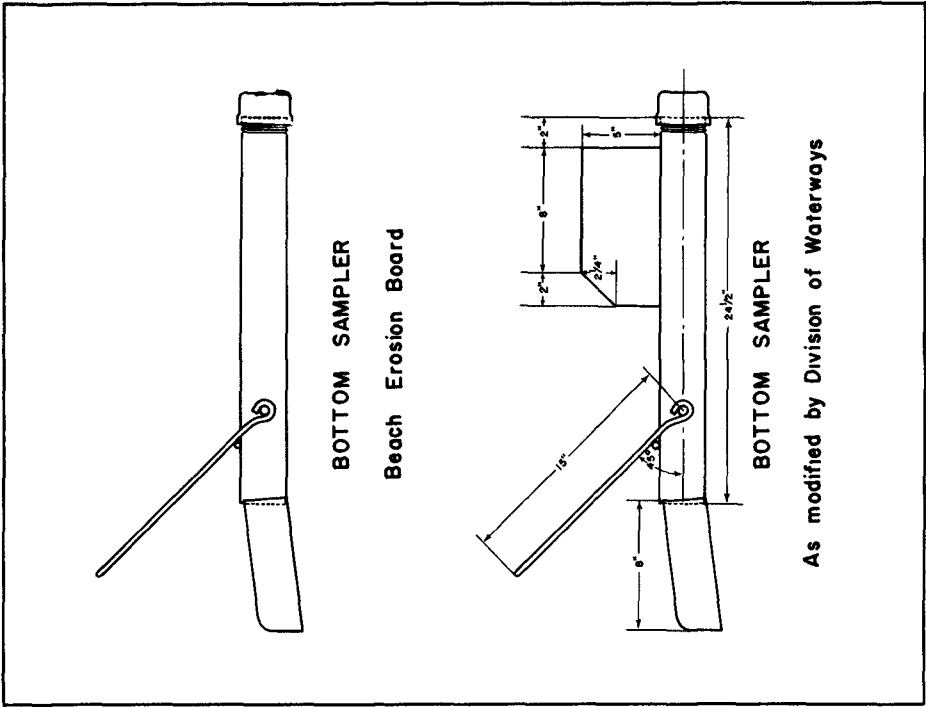


Fig. 3

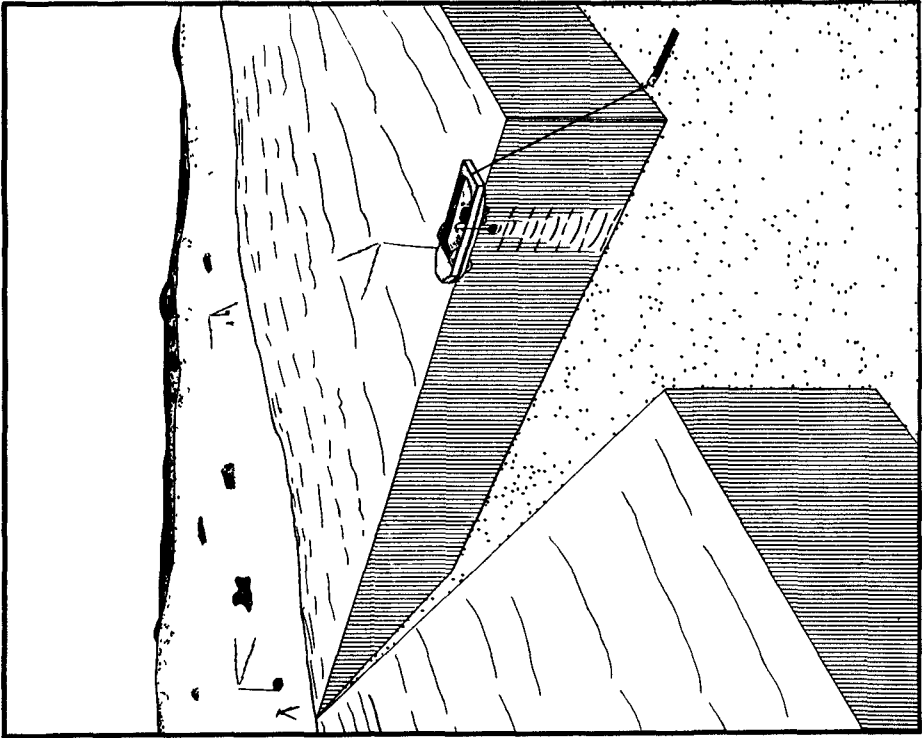


Fig. 2. Diagram of sounding and bottom sampling operation.

SOME CHARACTERISTICS OF BOTTOM SEDIMENTS ALONG THE ILLINOIS SHORE LINE OF LAKE MICHIGAN

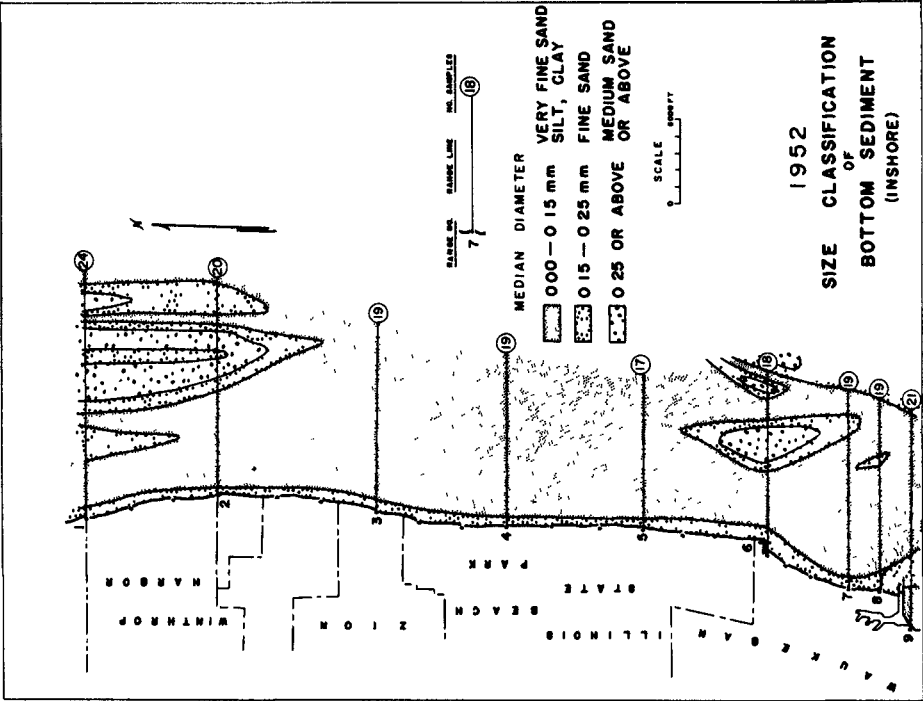


Fig. 5.

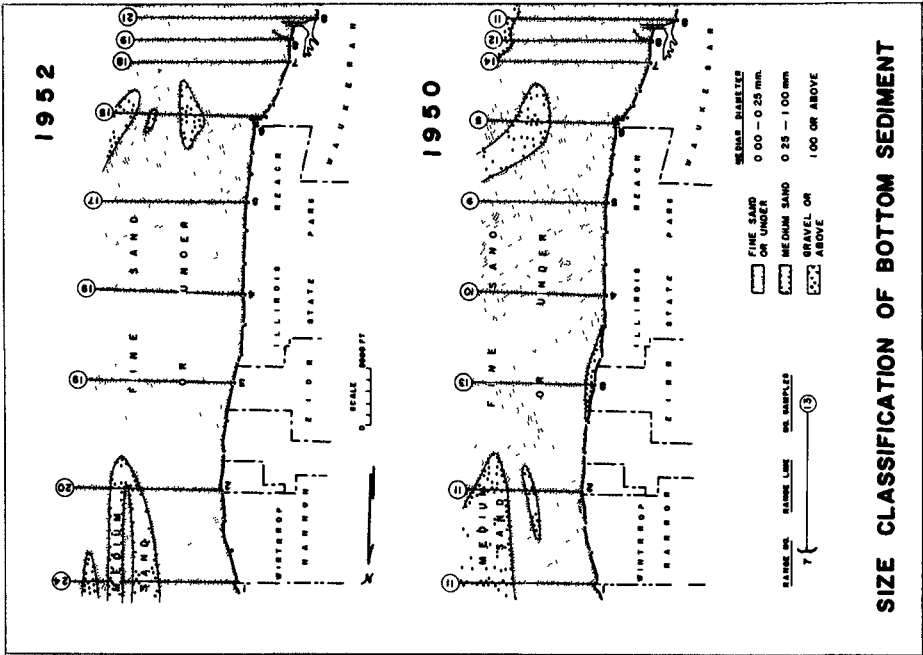


Fig. 4.

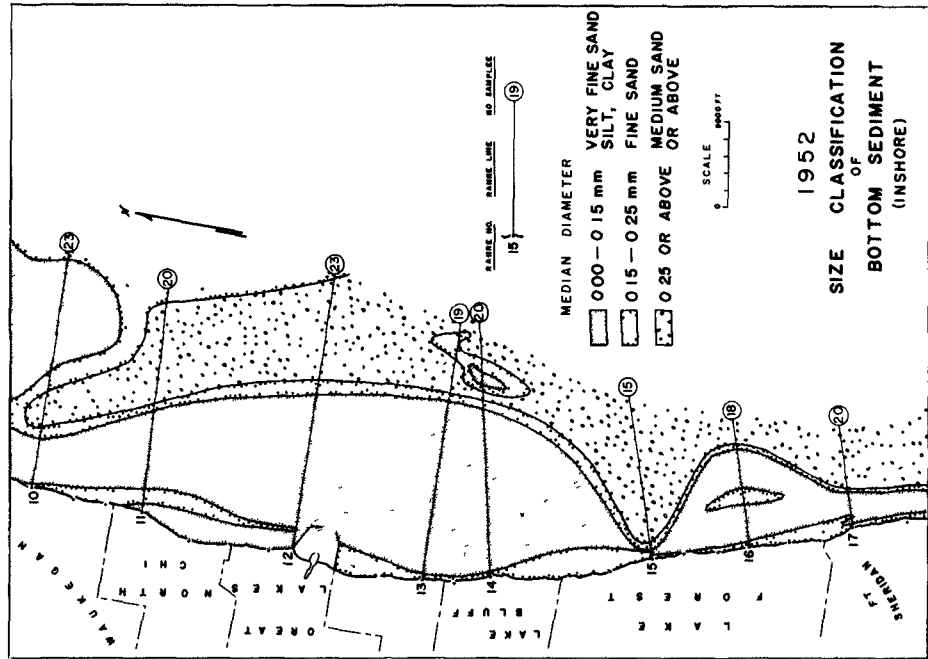


Fig. 7.

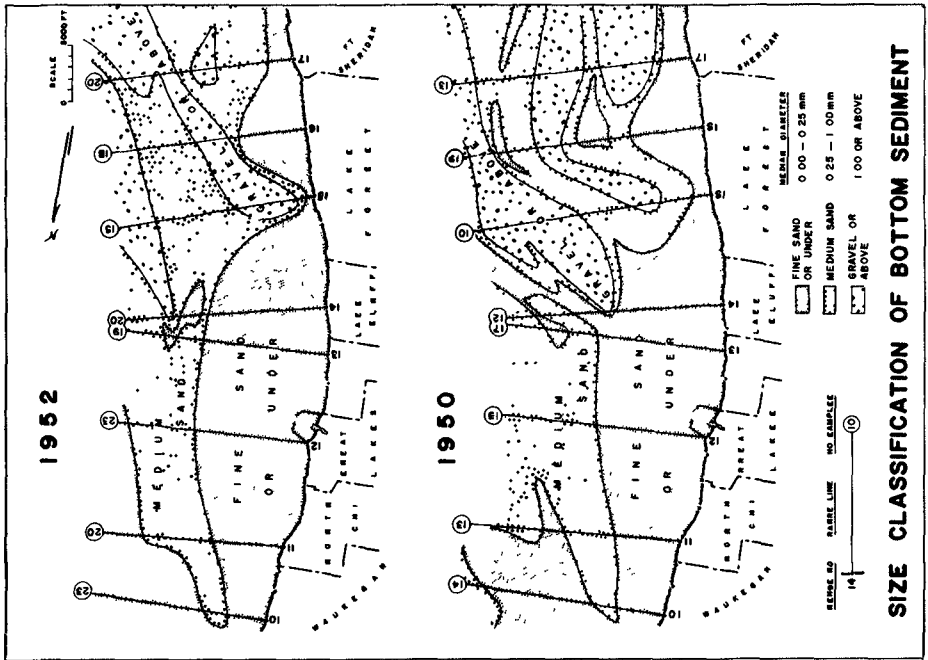


Fig. 6.

SOME CHARACTERISTICS OF BOTTOM SEDIMENTS ALONG THE ILLINOIS SHORE LINE OF LAKE MICHIGAN

fine sands are well sorted, having coefficients of from 1.1 to about 1.6. The foreshore bottom slopes vary in this section from about 1 on 25 at the Wisconsin State line to about 1 on 65 immediately above Waukegan Harbor. From the records of accretion above the harbor, it is evident that the predominant sand movement is in a generally southward direction and is of considerable amount. Fig. 6 is the plot of the median diameters from Waukegan through Fort Sheridan. This area is in the Lake Border Moraine section and is characterized by erosion along the entire reach except immediately above Great Lakes Harbor. As shown by the plot, the inshore area is composed entirely of fine sand or under, with a greater amount of medium sand offshore and the presence of gravel or above showing up off Lake Bluff, Lake Forest and Fort Sheridan. Again the similarity between the 1950 and 1952 survey results are apparent. Fig. 7 shows the further breakdown of the fine sands in the inshore area. As in the reach from the Wisconsin State Line to Waukegan, there is a narrow band of fine sand present along the immediate shore. However, it can be noted that this sand is apparently not a continuation of that occurring along the shore above Waukegan. Waukegan Harbor has seemingly diverted the sand above the harbor offshore with a portion of it extending both north and south of the harbor. Very fine sand or under occurs off Great Lakes and this covers a considerable area. Again the fine sands show good sorting with coefficients ranging from 1.1 to 1.7. The medium sands and the gravels have a coefficient of from 2.0 to about 6.0. The shore line from Waukegan to Great Lakes is largely protected by rip rap but the natural foreshore slopes in this reach were very steep. The foreshore slopes immediately above Great Lakes are about 1 on 55 and these steepen to about 1 on 20 or below near Fort Sheridan.

Fig. 8 is a continuation of the median diameter plot and covers that reach from Fort Sheridan south to Kenilworth. The 1950 Survey, due to unfavorable weather, was discontinued at Highland Park, so for comparison purposes, the 1946 Survey was plotted for the area southward of that point. Sufficient samples were not taken during this survey to adequately define this area, and therefore, the comparison from this point southward will not be in complete agreement.

This reach is a continuation of the Lake Border Moraine Section. The inshore area is still characterized by a narrow band of fine sand or under, but the offshore area shows an increasing amount of medium sands and gravels in apparently no explainable pattern. Southward from the northern limits of Glencoe, the drag sampler did not obtain samples of sufficient quantity for analysis in the areas shown as medium sands and gravels. A drop type sampler similar in design to that used by Dr. Hough of the University of Illinois was developed and samples of about 2 inches in depth were obtained in these areas. The interesting feature of these samples is that this offshore area is shown to be composed of clay overlain with a very thin layer of medium sands and gravels on the surface. Therefore, the pattern of offshore gravels and medium sands is possibly in error and misleading. However, the size distribution as shown seems to be indicative of the characteristics of the surface materials along this reach.

Fig. 9 shows the further classification of the inshore sediments. The immediate offshore area is again composed of fine sand with very fine

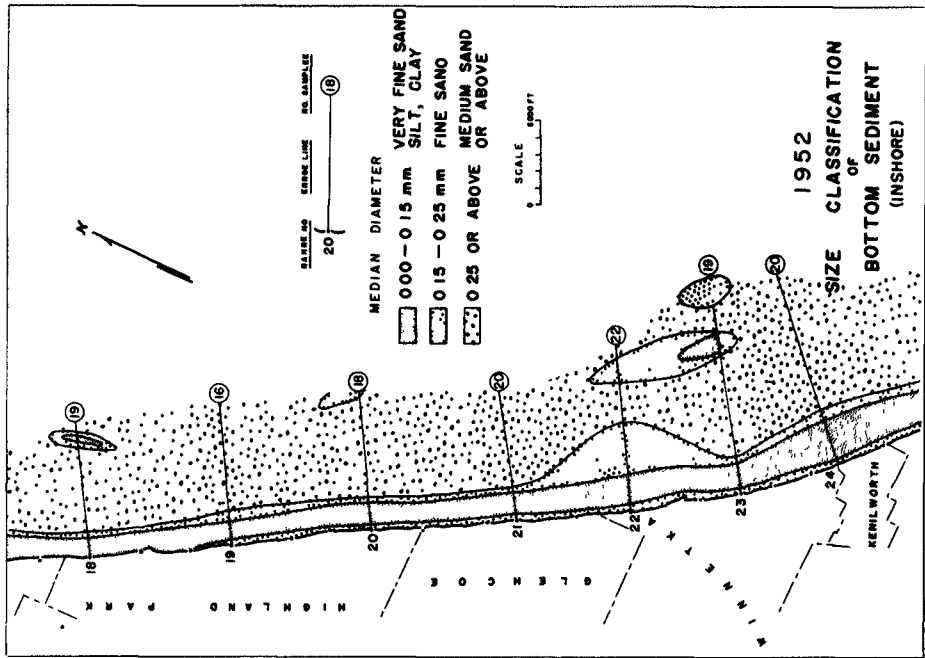


Fig. 9.

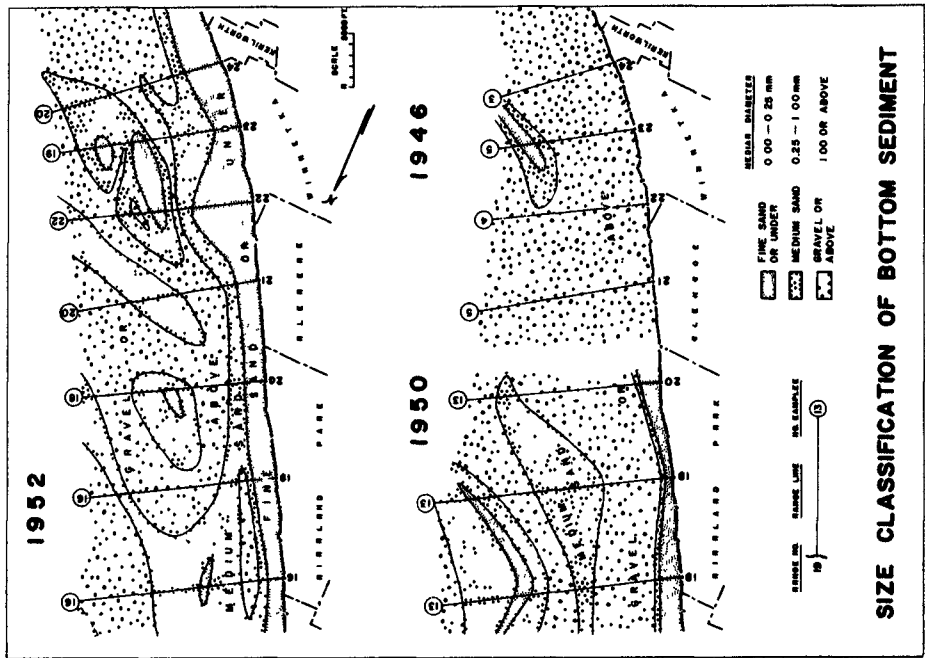


Fig. 8.

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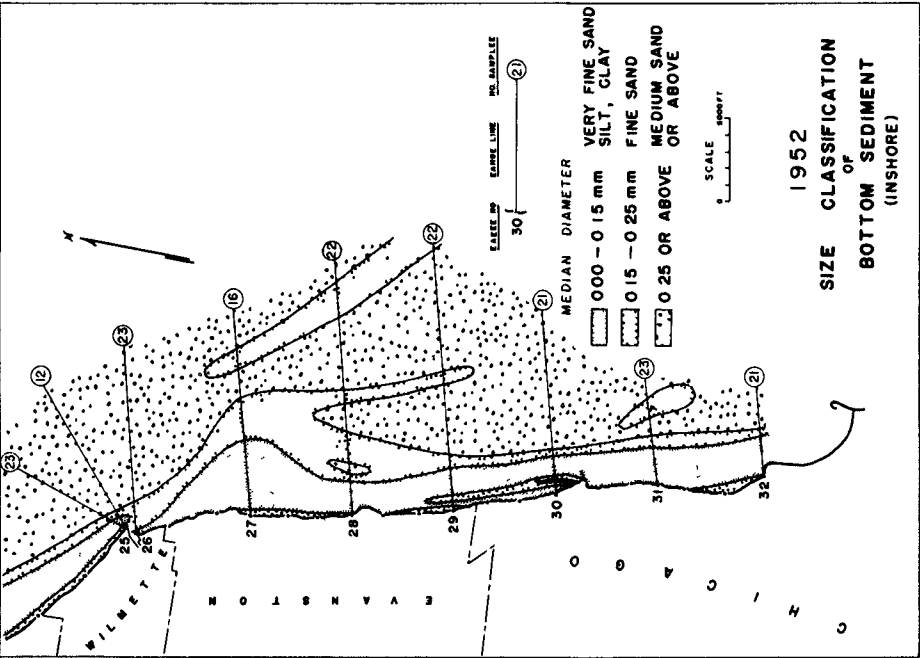


Fig. 11.

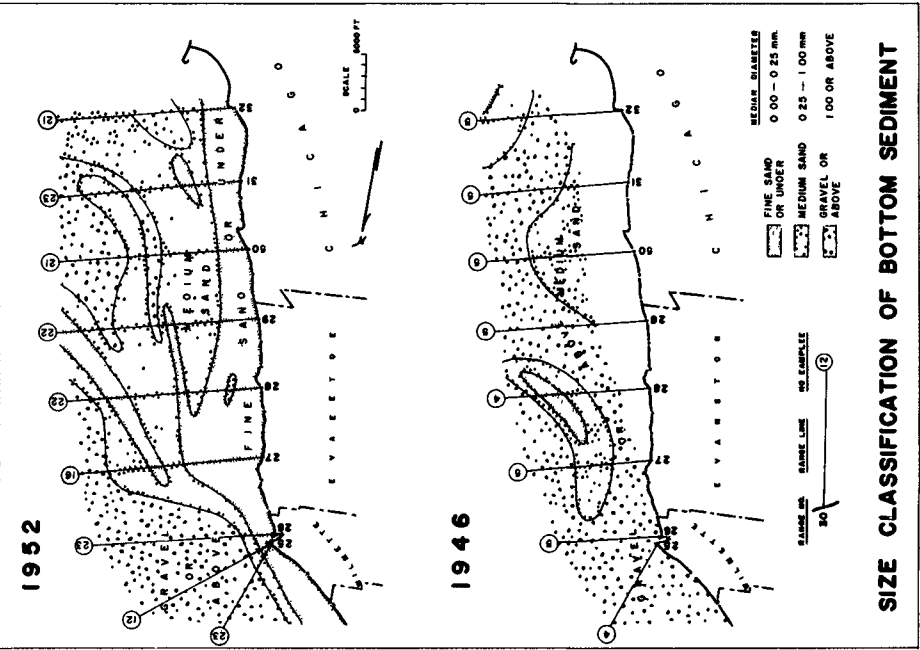


Fig. 10.

COASTAL ENGINEERING

sand further offshore. However, in this reach, the area of very fine sand is relatively narrow and is completely bounded on the east by another strip of fine sand. The sorting coefficients again vary from about 1.1 to 1.5 for the fine sands and from 2.0 to 6.0 for the medium sands and gravels. Foreshore bottom slopes in this area are from 1 on 12 to 1 on 20 and are fairly uniform from north to south.

Fig. 10 is the median diameter plot from Kenilworth to Foster Avenue at Chicago. The reach from Kenilworth to Wilmette Harbor is a continuation of the Lake Border Moraine Section and that below Wilmette is in the Southern Lake Plain Section. This reach again has the inshore area of fine sands or under and the offshore has more medium sands, fine sands and less gravel than the area immediately north. The drop sampler was also used in this area for the gravel and some of the medium sand areas and these areas were also found to be composed of clay overlain with very thin layers of sand and gravel on the surface.

Fig. 11 shows the further classification of the inshore sediments. Below Wilmette Harbor, the inshore area of fine sand is not continuous along the beach as was the case in the areas to the north. The continuation of the fine sands above Wilmette Harbor are now offshore about 2000 ft. Except in isolated locations, the very fine sands are immediately adjacent to the shore. The shore immediately below Wilmette Harbor is not largely protected by bulkheads and rip rap but in the unprotected areas, the foreshore slopes are on the order of 1 on 10 to 1 on 15. The sorting coefficients of the fine sands and under are still on the order of 1.1 to 1.6 and the medium sands and gravels from 2.0 to 7.0.

Fig. 12 shows three typical profiles of the lake bottom with the complete median diameter size classification of the samples taken. This classification is that used by the U.S. Bureau of Soils. The first profile was taken off the Illinois Beach State Park, the second at Fort Sheridan and the third at the southern city limits of Evanston.

The above comments and illustrations have been concerned with the general overall characteristics of the bottom surface sediments in Lake Michigan along the Illinois shore line. In addition to this study, a detailed sampling program has been in progress for certain selected groin systems. Samples and soundings have been taken at regular intervals on 8 groins in the Lake Bluff area. These groins were constructed by a landowner who was suffering extensive loss of land due to erosion of the high bluff fronting on the lake. The groins were constructed in 1952 and have, as yet, only partially controlled the bluff erosion. Eight sampling ranges and seven additional sounding ranges were established. Ten samples per range were taken out to a depth of 15 feet. Fig. 13 shows the median diameter plot of these samples.

Prior to the groin construction, surveys indicated that only fine and very fine sands were present. It will now be noted that the groins have sorted and held inshore those medium gravels of 1.00 mm or above in median diameter with a narrow band of coarse and medium sand offshore of the gravel, and fine sand adjacent to the coarse and medium sand. Very fine sand is still present further offshore outside of the action of the groins.

SOME CHARACTERISTICS OF BOTTOM SEDIMENTS ALONG THE
ILLINOIS SHORE LINE OF LAKE MICHIGAN

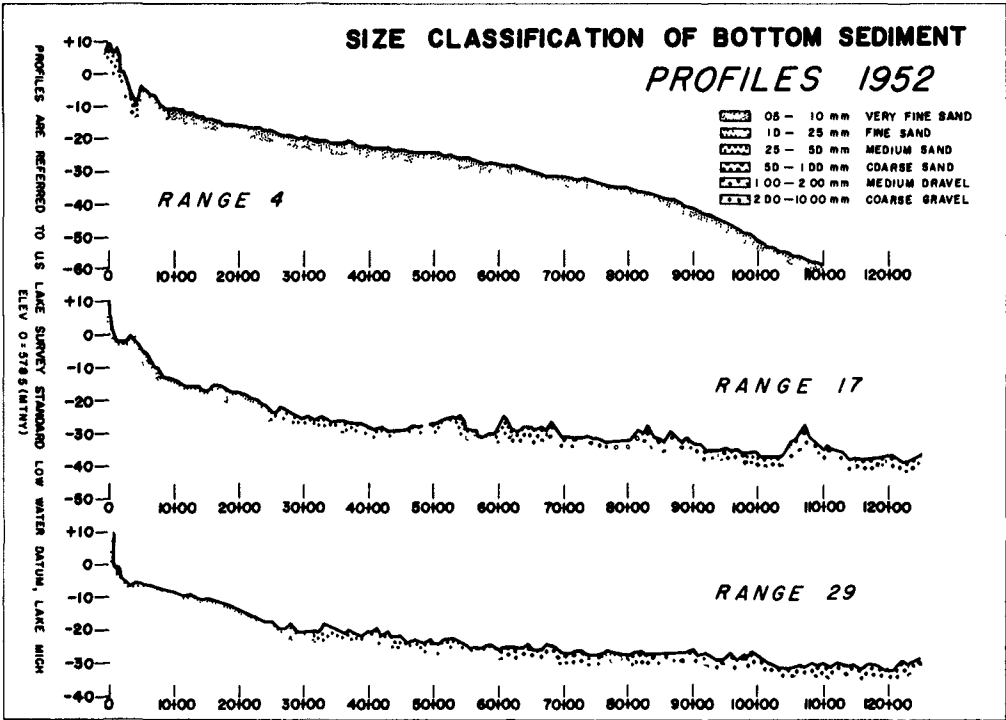


Fig. 12.

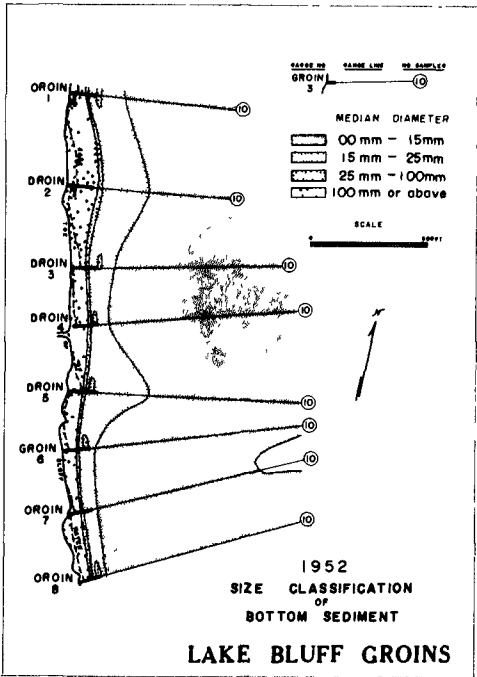


Fig. 13.

COASTAL ENGINEERING

The work which has been done to date on bottom sediment characteristics has been confined to the sounding, sampling, and analysis mentioned, plus limited studies of results. At present, it appears desirable to continue the present survey program, with such modification as may be indicated from time to time, and in addition it seems desirable to make a determination of offshore sources of beach material as to areal extent and depth of various materials.

Some of the things which may be determined by study of the surveys are:

1. The behaviour of bottom sediments when acted upon by the various physical forces.
2. The effects of the characteristics of bottom materials upon the stability of beaches.
3. A more intelligent design of shore protection structures and protective beaches.
4. The availability of materials for maintaining or replenishing beaches.