Application of Discriminant Analysis and Manova to Grain-Size Data on a Study of the Distribution and Movement of Dredged Sediment

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ABSTRACT / A dredged material disposal operation was monitored at a location in Lake Erie, 8 km offshore at Ashtabula, Ohio, in 1975. Approximately 200 sediment cores were collected from 12 experimental and 4 control locations before and after dredging and analyzed for the grain-size distribution and related heavy-metal content.

The dredged sediments were similar to those from the lake bottom at the disposal and control sites. Because of this similarity, it was extremely difficult to distinguish between the dredged material and the lake bottom sediments without tagging the material with dyes or radioactive isotopes. A sequence consisting of a linear discriminant analysis followed by a univariate and multivariate analysis of variance was successfully applied to discriminate between the dredged and the original lake sediments. Results indicate that 4 months after the disposal operation some stations had returned to predisposal conditions, a probable result of currents stripping dredged material off the lake bottom. The analysis of variance indicated that the clay-size fraction was responsible for initial changes in the grain-size distribution. Storm induced scouring caused an eventual return of the grain-size distribution to predisposal conditions.

In support of this observation, the concentrations of iron and zinc, which were statistically correlated to the clay size fraction, also exhibited the same trends.

Introduction

A dredging disposal operation, funded by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi, was monitored (Danek and others 1977, Wyeth and Sweeney 1978) at a location 8 km offshore at Ashtabula Harbor in Lake Erie, Ohio (lat. 41°57'46"N, long. 80°47'44"W), as shown on Fig. 1. One of the processes studied was the distribution and movement of the dredged sediments after deposition.

A number of attempts to determine the amount and direction of sediment transport in environments similar to that in Lake Erie have been reported, using geophysical or radioactive techniques (Durham and Goble 1977, Leahy and others 1976, McClennen and Kramer 1976, Pezetta 1974). These studies have met with limited success in tracking sediment movement.

Statistical methods, including trend surface analysis (McBride 1975), and cluster analysis (Ali and others 1976) of grain-size data, have been investigated as well. These methods, however, also present difficulties in tracking dredged material where the sediments of the original lake bottom are indistinguishable from the disposed material.

Prediction of sediment-transport rates by measuring flow conditions has also been unsatisfactory. Problems have occurred in accurately determining the critical erosion velocity of the currents (or boundary-shear stress). Efforts to measure this parameter for various grain sizes have been made in both the marine environment and in the laboratory (e.g., Sternberg 1972, Sundborg 1967, Hjulstrom, 1939). Results from these studies, however, show considerable variation, and estimates of sediment transport based on the methods employed in them can be considered only approximations.

A multivariate approach using sedimentological characteristics (grain size) coupled with geochemical characteristics (heavy-metal concentrations), indicated that the replicates of the lake sediments were more homogeneous in terms of grain-size distribution than the replicates of the dredged sediments. Therefore, an approach was chosen using the homogeneity of the replicates as the distinguishing factor. The strategy used

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Figure 1. Location of sampling stations at the control and disposal sites. Stations D1-D12 are the sampling locations from the 1975 study discussed in this paper. ND (new disposal site) is the 1976 disposal site. The crosshatched area is the area designated as a potential disposal site.