1991

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1991. *Transactions of the Nebraska Academy of Sciences,* XVIII: 11–17

CROSS-SECTIONAL ANALYSES OF SEDIMENT AND ORGANIC MATTER FROM TRANSECTS ACROSS THE LOWER UNCHANNELIZED MISSOURI RIVER

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Federal Aid in Fish Restoration, Dingell-Johnson Project F-75-R-7 Job No. 1. March 1990

The United States Army Corps of Engineers, U.S. Geological Survey, and Nebraska Game and Parks Commission cooperated in 1989 to obtain physical data from cross-section transects along the unchannelized Missouri River in northeastern Nebraska. Bed-sediment samples were collected from locations along these transects and taken to the laboratory. Mean particle-size and standard deviation were determined by weighing material retained on seven U.S. Standard sieves after being on a sieve shaker for six minutes. Organic matter content of each sample was obtained by ashing an aliquot in a muffle furnace to remove the organic portion. A new system for coding sediment mixtures was developed, and coded sediment and organic matter content were compared with depth and velocity in a regression analysis. The most common mean particle-size was determined to be medium sand; however, some samples were as coarse as fine gravel. Organic-matter content was less then 3% for the most part; however, it was measured as high as 20%. Sediment and organic matter were related to depth and velocity; however, r-square values were low, suggesting that other factors contribute to the observed variability in the sediment mixtures and organic matter content.

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INTRODUCTION

Federal (U.S Army Corps of Engineers and U.S. Geological Survey) and state (Nebraska Game and Parks Commission) personnel cooperated to obtain physical data for use with a stream habitat model. The study area included the unchannelized Missouri River from Yankton, South Dakota, to Ponca, Nebraska. The purpose of these studies was to define habitat-suitability criteria for use with the Instream Flow Incremental Methodology (IFIM). IFIM is a tool used to evaluate the environmental consequences of water-and-land-use practices (Bovee, 1986).

Physical data were collected from six cross-section transects in March, 1989, and eight cross-section transects in July, 1989. Existing transects, established by the U.S. Army Corps of Engineers, were used. Transects were chosen to represent the total range of existing habitat along this reach of the Missouri River. March data were acquired in a period of low discharge (8,935 cubic feet per second [cfs]) and July data were acquired in a period of higher discharge (31,563 cfs). These were mean values for the period and were provided by the U.S. Army Corps of Engineers (1990). Measured parameters included stage, discharge, velocity, substrate, and cover, as well as water, river-bed, and land surface elevations. This paper addresses a qualitative analysis of sediment samples only. Moreover, only July sediment data will be described, because March samples were visually inspected and coded according to Bovee (1982).

Sediment data, at the present time, are not incorporated in the IFIM models (e.g. PHABSIM); however, there undoubtedly is a relationship between biota and sediment/organic matter mixtures. This paper addressed the relationships which exist between sediment mixtures and other physical variables such as depth and velocity. Moreover, these parameters are influenced by the annual operating procedures for the main stem and tributary dams.

Other members of the study team will prepare reports dealing with other aspects of these studies. It is important to point out that data acquisition flowed from a coordinated team of researchers who should all be acknowledged as co-producers of any insight obtained from these studies. Team members by agency included: Nebraska Game and Parks Commission–Larry Hutchinson, Steve Satra, Steve Schainost, Brad Newcomb, Pat O'Brien, and Joe Cassidy; U.S. Geological Survey–Joe Gorman, Jim Sondag, Jim Wellman, Dave Conell and Bill Matthes; U.S. Army Corps of Engineers–Doug Latka, Mark Harborg, Mark Mills, Marion Bergman-Ingwerson, Tom Curran, John Garrison and Larry Morong.

METHODS

Sediment samples were collected from the river bottom with a pipe dredge and with a BM54 bed sampler. Depth, velocity and bottom elevation were measured at the same location. Sediment samples were placed in a "whirl pac," preserved with formalin, and labelled with a station number corresponding to the distance in feet from a left bank (facing downriver) range marker. Sediment samples were dried at 105°C for four hours; after drying a one-half tablespoon aliquot was removed and stored by freezing for organic matter analysis.

Sediment samples were broken apart with a mortar and pestle and placed in an electric sieve shaker. Samples were shaken for six minutes. The stack of U.S. Standard sieves included Numbers 4 (4.76 mm), 10 (2.00 mm), 20 (0.84 mm), 35 (0.50 mm), 60 (0.25 mm), 120 (0.125 mm), and 230 (0.0625 mm). Material retained on a No. 4 was called fine gravel, No. 10 very fine gravel, No. 20 very coarse sand, No. 35 coarse sand, No. 60 medium sand, No. 120 fine sand, No. 230 very fine sand and that passing through No. 230 was called silt/clay (Dapples, 1959; Platts, 1983).

The material from each sieve was carefully brushed onto a tared weighing dish and weighed to the nearest hundredth of a gram. Each station sample was subsequently composed of eight weight measurements (one from each sieve). Mean particle-size and a standard deviation were determined for each sample. Though the distribution of particle size about the mean suggested the distribution was slightly skewed, the data were not transformed (Dapples, 1959). Once these data have been transformed, negative values can cause the mean to approach zero. We wanted a relative measure of station sediment-variability and the coefficient-of-variation (CV) was the statistic of choice (Steele and Torrie, 1960). CV is not as meaningful when mean values are near zero. Therefore we converted the untransformed standard deviation to a coefficient-of-variation. Mean particle-size was used to compare with depth and velocity at stations along cross section transects to define the relationship between these variables.

Since river-bed materials are a mixture of different particle sizes and codifying in the field may not be easily replicated, we devised a different numerical code system. The method included the collection of preserved samples from the field, which was not especially time-consuming. The sample was separated onto a series of sieves in a sieve shaker, which required about seven minutes per sample to complete (including weighing). Eight sediment class codes were defined as follows: class code 1 = fine gravel; 2 = very fine gravel; 3 = very coarse sand; 4 = coarse sand; 5 = medium sand; 6 = fine sand; 7 = very fine sands; 8 = silt/clay. The calculated mean particle-size at a station was called the dominant type and, on the basis of which class code it fell into, was assigned that class code. The relative amount of variation (CV) in each station is represented by the decimal place in the code. The calculated CV was assigned a code as follows: less than 50 = .0, 50–100 = .1, 100 –150 = .2, 150–200 = .3, 200–250 = .4, 250–300 = .5, 300–350 = .6, greater than 350 = .7 (where .0 represents low variability and .7 is high variability). CV can only be used to compare relative variability between stations. Brusven's (1977) descriptor for embeddedness established two groups (i.e. dominant and sub-dominant) and the two types were assigned a relative importance (percent composition). The embeddedness factor was the highest percent expressed as a decimal. This works best when only two types are represented in the sediment mixture. Bovee (1982) and Platts (1983) modified the Brusven index by using an estimated percentage of fines for embeddedness. Our index used actual mean particle-size and a measure of the actual range of sizes to define a mixture. We did not attempt to embed one sediment type into another. We feel our system is analytical and subject to less inaccuracy, which can result from visual classification schemes. It is somewhat more time-consuming.

Total organic matter content was obtained by combustion of the organic fraction at 600°C in a muffle furnace for three hours. Organic matter was presented as a percentage by weight of each station sample.

RESULTS

The Missouri River between Yankton, SD (river mile 806) and Ponca State Park, NE (river mile 753) is 53 miles long and unchannelized. The reach lies downstream from Gavins Point Dam and is undergoing channel-bed degradation due to the deposition of sediment upstream in Lewis and Clark Lake. The U.S. Army Corps of Engineers has obtained river-bed elevations from 33 ranges (transects) in this reach. Schmulbach et al. (1981) inventoried the aquatic habitat in this reach. His data were used to characterize habitat on each of these 33 transects. Subsequently all transects were grouped into eight types, and one range from each type was sampled during 1989 as described in the methods section.

The transects chosen for this study included a representative of each type as follows: 755.56 was narrow (2,400 feet) and divided into two channels by a shallow sandbar; 778.9 was wide (4,800 feet) with a braided complex; 780.91 was wide (5,400 feet), braided and with a chute; 783.61 was divided with a flow in each channel at all times (5,400 feet); 786.73 was narrow (1,600 feet) with no shallow bars; 793.6 was wide (2,800 feet) with a chute and pool; 797.5 was intermediate width (2,400 feet) with a chute; 804.28 was wide (3,500 feet), divided and with a sandbar complex. Raw data included the coded sediment mixture and percentage of organic matter by station (station = the distance in feet from the left bank range marker for each transect). These data appear in an annual Federal Aid report (Hesse and Mestl, 1990). We performed simple linear regression analysis using depth vs sediment, velocity vs sediment, depth vs organic matter and velocity vs organic matter for each transect (Table I). We plotted bed elevation, coded sediment mixtures and organic matter percentage by station for each transect (Fig. 1).

DISCUSSION

Mean particle-size along transect 755.56 ranged from very coarse sand to medium sand with only one outlier. At 1,620 feet (Table I) a sample of fine gravel was located on the sloping bank of the deepest channel (Fig. 1). The lowest organic matter content was in this same stratum. The organic matter composed less than 2% (by weight) at nearly all stations; however, it reached nearly 20% of one sample in the small backwater on this transect.

The variation in particle size was very low for most stations on 778.9 (Table I). The predominant particle size classified most samples as medium sand. Outliers included a few instances where fine sand occurred and one instance of very fine gravel. The coarsest sediment was once again found in the deepest channel; however, a stratum of the finest sand on the transect was also found in this same channel. Organic matter content was variable; it ranged from 0.3% to nearly 8%. The transect 780.91 was wide and braided. Mean particle-size varied more on this transect than on most others. The organic matter content was variable as well, and the highest values were found in the channels.

A large timbered island divided 783.61 into two permanent channels. Mean particle-size was dominated by medium sand. Channel-bed degradation has been severe at this location and lateral meander has all but stopped. The island might have been expected to contribute a large amount of organic material; however, this did not appear to be the case since sediment organics were low throughout the transect.

Transect 786.73 was nearly U-shaped. This was also the narrowest location studied. Mean particle-size seemed to be slightly larger, and many stations were classified as coarse sands. Organic matter content varied from 0.5% to 13%. The highest organic matter values occurred in the right bank channel. This channel impinges a timbered bankline which has periodically sloughed into the river. The river channel and adjacent bankline contains many downed trees.

The main channel at 793.6 was found to contain coarse sediments. Many of the stations were classified as fine gravel. Organic matter content was varied and even though the sediments were coarse, organics were as high as 12%.

Transect 797.5 was similar in shape to 786.73. Mean particle-size was more variable on 797.5, and more stations showed coarse sediments. For the most part, organic matter content was low. A high spot in the left bank channel was found to contain sediment with 12% organics. This may have been an old tree line where roots would have armored the sediments and prevented erosion of this knoll.

The last transect (804.28) was unique because of the midriver sandbar complex. There were many big tree trunks protruding from the channel along the right bank. This was obviously an old stand of timber; by its degraded appearance it was claimed many years before. The bottom was armored with coarse sediments and this may account for why these tree trunks remained very firmly in place.

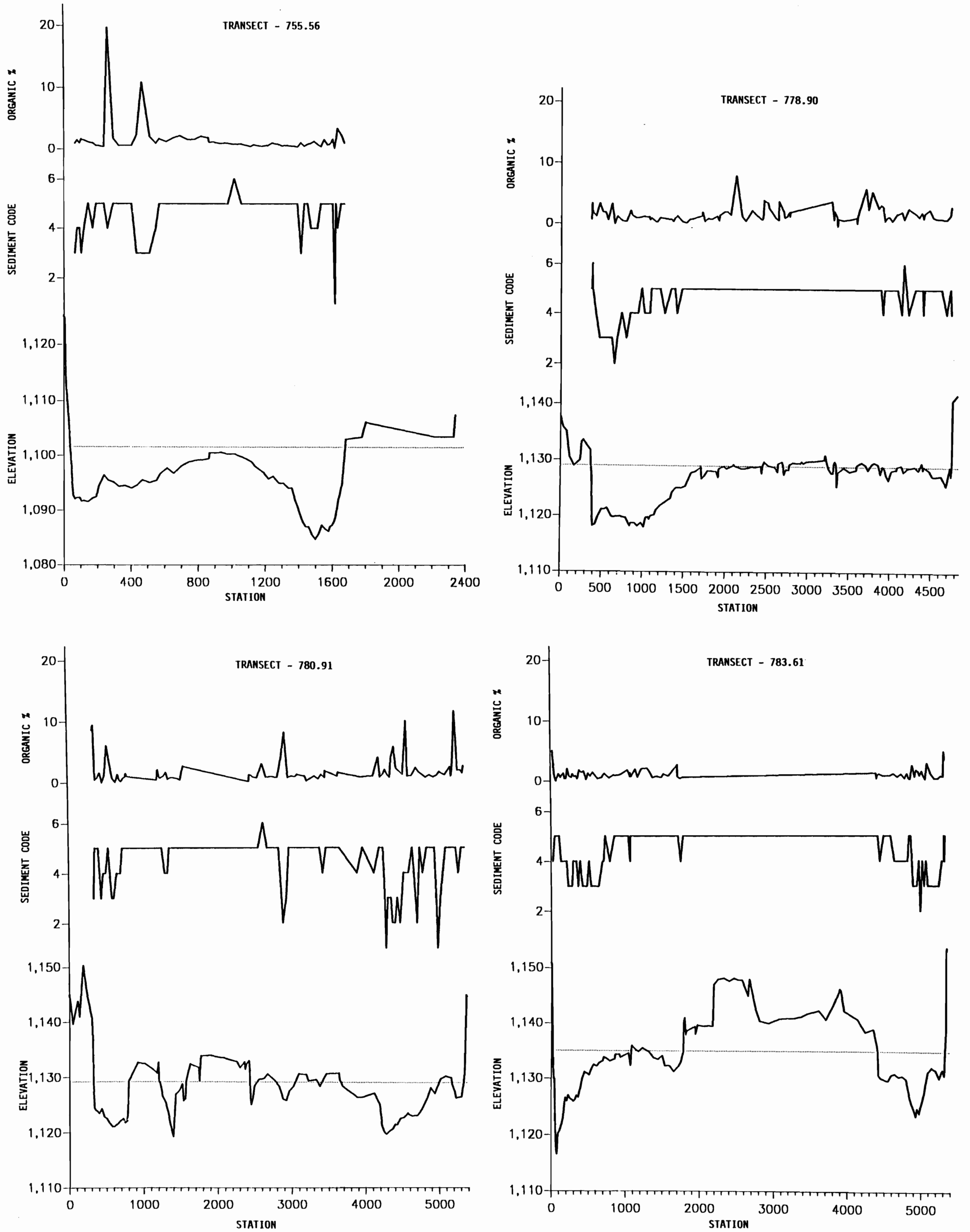

Figure 1. River-bed elevations, sediment codes, and organic content from eight cross-sectional transects from the unchannelized Missouri River.

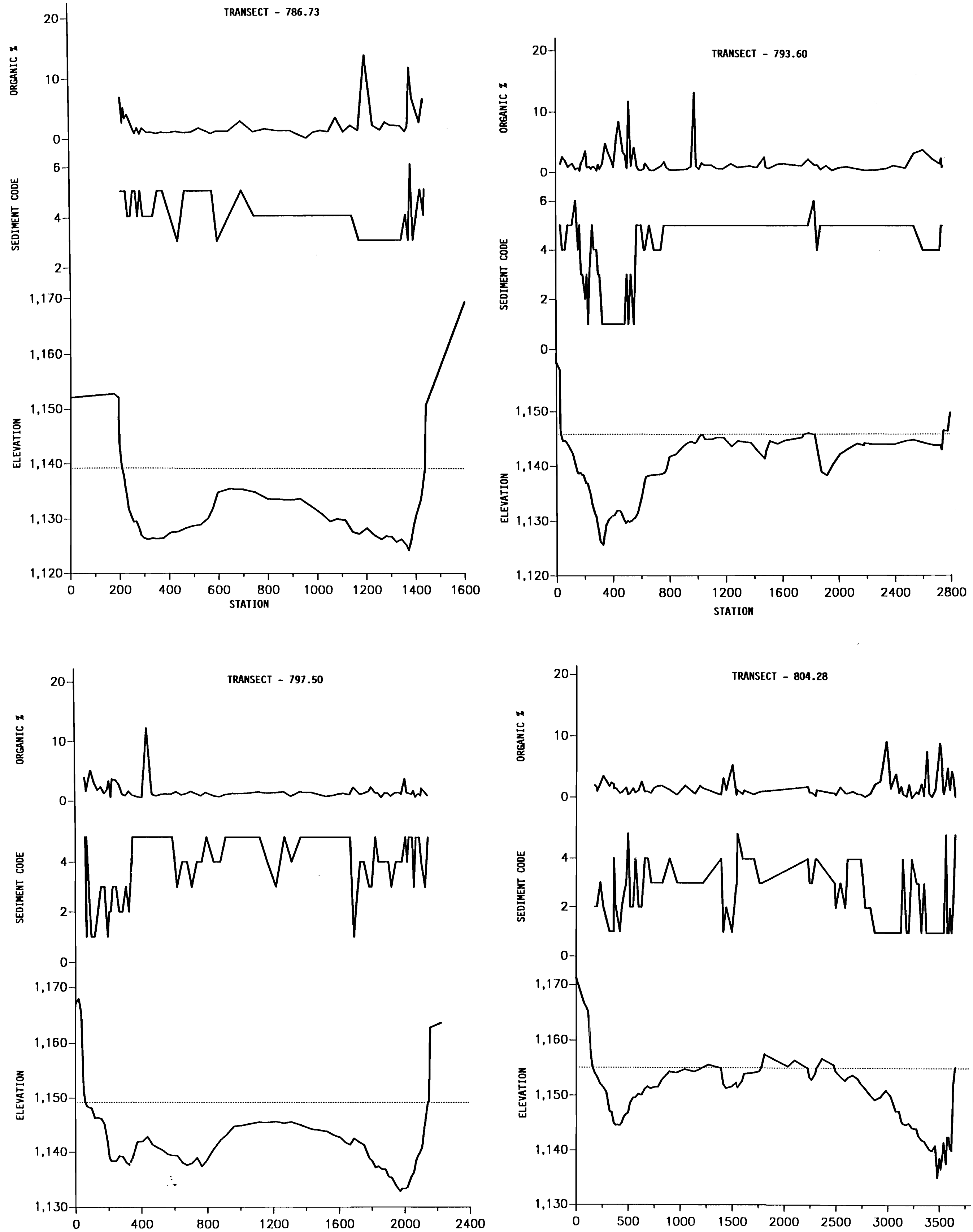

Figure 1., continued.

Table I. Relationship between depth, velocity, sediment, and organic matter content measured on eight cross-section transects in the lower unchannelized Missouri River, 1989.

Transect	Test	r^2	F	P>F
755.56	Depth/Sediment	0.096613	6.63	0.0124
778.9	Depth/Sediment	0.415246	76.69	0.0001
780.91	Depth/Sediment	0.239606	27.73	0.0001
783.61	Depth/Sediment	0.040476	3.42	0.0682
786.73	Depth/Sediment	0.110062	6.18	0.0163
793.6	Depth/Sediment	0.550665	109.07	0.0001
797.5	Depth/Sediment	0.002148	0.17	0.6850
804.28	Depth/Sediment	0.228553	25.18	0.0001
755.56	Velocity/Sediment	0.031914	2.01	0.1613
778.9	Velocity/Sediment	0.421647	66.34	0.0001
780.91	Velocity/Sediment	0.188720	19.77	0.0001
783.61	Velocity/Sediment	0.236387	23.53	0.0001
786.73	Velocity/Sediment	0.221721	13.67	0.0006
793.6	Velocity/Sediment	0.374239	50.83	0.0001
797.5	Velocity/Sediment	0.116841	9.92	0.0023
804.28	Velocity/Sediment	0.219850	21.98	0.0001
755.56	Depth/Organic	0.009199	0.58	0.4509
778.9	Depth/Organic	0.087624	10.37	0.0017
780.91	Depth/Organic	0.025761	2.30	0.1330
783.61	Depth/Organic	0.005886	0.48	0.4906
786.73	Depth/Organic	0.005911	0.30	0.5880
793.6	Depth/Organic	0.091546	8.87	0.0037
797.5	Depth/Organic	0.029808	2.37	0.1281
804.28	Depth/Organic	0.003870	0.33	0.5670
755.56	Velocity/Organic	0.000070	0.00	0.9481
778.9	Velocity/Organic	0.091600	9.18	0.0032
780.91	Velocity/Organic	0.006364	0.54	0.4653
783.61	Velocity/Organic	0.000018	0.00	0.9708
786.73	Velocity/Organic	0.050507	2.55	0.1166
793.6	Velocity/Organic	0.036181	3.15	0.0794
797.5	Velocity/Organic	0.050415	3.98	0.0496
804.28	Velocity/Organic	0.048295	3.96	0.0501

Moreover, the sediments in this old stand of trees contain high organic matter content.

Sediment mixtures proved to be correlated more closely with depth and velocity than organic matter (Table I). The *r*-square values were not high, which would suggest that depth and velocity were not the only factors which contributed to the variability in transect sediment type. The same could be said for the organic matter content of the sediments.

FINAL COMMENTS

Fish may be oblivious, at times, to the bottom substrate. At other times, in particular during reproductive periods or in search of invertebrate food items, they undoubtedly select specific bed sediments. We have begun to collect benthic insects along with sediment data, velocity, depth and water clarity. These data will help clarify the role sediment type may play in the life cycle of Missouri River macroinvertebrates.

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