A Final Report on the Effects of Dredging and Spoil Disposal on the Sediment Characteristics of the Clam Flats of the Lower Kennebec Estuary

Submitted to: Maine Department of Environmental Protection
Augusta, Maine 04333

Submitted by: Peter F. Larsen and Anne C. Johnson
Bigelow Laboratory for Ocean Sciences
West Boothbay Harbor, Maine 04575

March 25, 1982

Bigelow Technical Report No. 24

TABLE OF CONTENTS

List of Figures

KENNEBEC SEDIMENT STUDY

INTRODUCTION

In 1975, the U.S. Army Corps of Engineers (COE) dredged sections of the lower Kennebec River, disposing of the dredged material in a scour basin approximately 1.8 miles downstream. Subsequently, local clammers claimed that the dredging caused siltation on the flats, and had an adverse effect on the clam harvest. In March 1980, the COE proposed another dredging project in the lower Kennebec River estuary. Approval by the Board of Environmental Protection was made subject to the condition that a monitoring program be carried out simultaneously with the dredging to evaluate the effects of the dredging and disposal operations on the clam flats. The Bigelow Laboratory was contracted to carry out such a program and this report presents the results of the study.

METHODS

In consultation with the Maine Department of Marine Resources (DMR), five flats were selected for sampling. They were selected on the basis of having commercially viable clam populations and to insure a distribution of sampling sites throughout the potentially affected area. At each flat upper and lower stations were located in the intertidal zone making a total of 10 stations (Fig. 1). The impact of dredging at

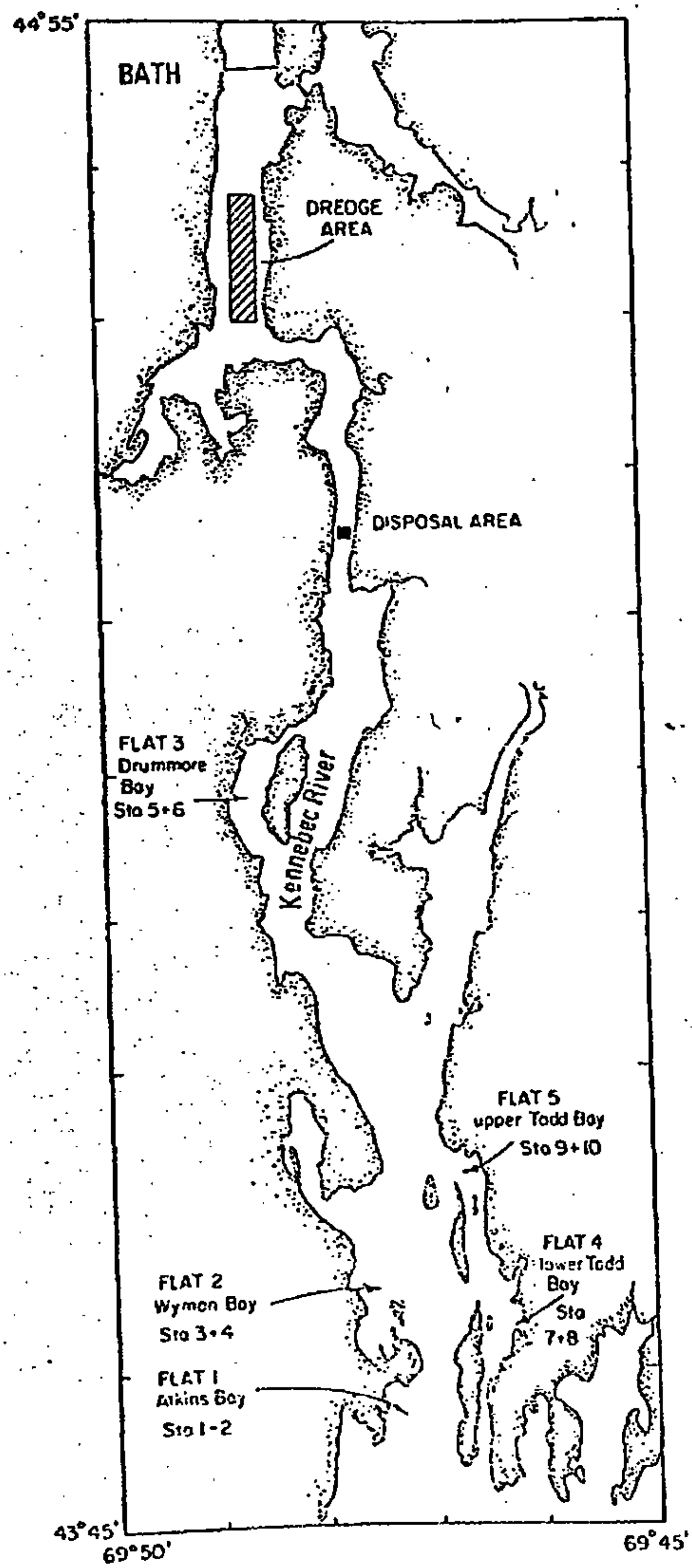

Fig. 1. Location of stations, and dredge and disposal areas in the Kennebec River estuary.

these stations was evaluated by both sediment flux and granulometric analyses.

Sediment flux was measured by the method of Gordon (personal communication). At each station a 15-20 cm pit was dug and a 0.2 m^{-2} plate placed in the bottom, levelled and buried. The plates were marked by two stakes placed 3 m from two sides of the plate at right angles to each other. Plates were buried at stations 1-6 on October 2, 1981, and at stations 7-10 on October 3, 1981. The level of the sediment over the plate was measured with a steel rod. The average of ten randomly placed probes was taken as the observation.

A 6.5 cm corer was used to collect a 6-10 cm deep sediment sample near each station. A sample of the dredged material was also collected.

The stations were sampled according to the following schedule:

1) 3 days prior to disposal (Oct. 5)
2) 1 day prior to disposal (Oct. 7)
3) The second day of disposal (Oct. 9)
4) The fourth day after the start of dredging (Oct. 12)
5) 1 day after cessation of disposal (Oct. 29, 30)
6) 1 week after cessation of disposal (Nov. 4)

Except for the fifth sampling, which was split between two consecutive low tides, all the stations were sampled during the same low tide.

The grain size data provided by the COE and the sediment depth data were entered and processed by the University of Maine Computer Center through the Bigelow Laboratory Computer Center. The mean, sorting coefficient and skewness were computed for the grain size data using standard formulas presented in Folk, 1968. The sediment depth data were analyzed using 3 factor ANOVA (analysis of variance).

RESULTS

The results of the sediment depth sampling are shown in Table 1. The net change in sediment depth over the course of the study, as shown by the difference between the average of the depths of all the stations on the first and last sampling dates, was a decrease of .50 inches. Plotting the observations for each station (Fig. 2) shows that the decrease was spread fairly even across both the stations and the sampling dates. Station 2 is an exception; sediment depth decreased from 5.01 inches to 3.05 inches. On the lower edge of a sand flat, this station probably sustained the highest energy input of all the stations sampled in this study. It equilibrated rapidly and exhibited different characteristics such as ripples and wave marks, on successive sampling dates. The upper station on this flat is protected by a small sand bar and showed little variation.

Although each station showed a net decrease in sediment depth, all except station 7 showed an increase at some point during the study. None of the stations showed an increase over two consecutive sampling dates. While the changes in sediment depth are statistically significant (see Appendix A) for all the stations between all sampling dates, these changes and the net loss could have been caused solely by natural causes, such as the spring and neap tidal cycle, annual

Table 1. Sediment depth measurements for Kennebec River estuary samples.

Flat	Station	Sampling Date	Sediment Depth (inches)	Standard Deviation
1	1	10-5	3.79	0.30
1	1	10-7	3.88	0.32
1	1	10-9	3.68	0.27
1	1	10-12	3.63	0.33
1	1	10-29	3.76	0.27
1	1	11-4	3.56	0.14
1	2	10-5	5.01	1.31
1	2	10-7	4.50	0.33
1	2	10-9	4.36	0.33
1	2	10-12	4.16	0.35
1	2	10-29	4.30	0.35
1	2	11-4	3.05	0.27
2	3	10-5	3.63	0.13
2	3	10-7	3.56	0.25
2	3	10-9	3.58	0.26
2	3	10-12	3.61	0.17
2	3	10-29	3.71	0.13
2	3	11-4	3.44	0.21
2	4	10-5	5.81	0.18
2	4	10-7	5.60	0.18
2	4	10-9	5.58	0.21
2	4	10-12	5.66	0.34
2	4	10-29	5.41	0.21
2	4	11-4	5.46	0.20

Flat	Station	Sampling Date	Sediment Depth (inches)	Standard Deviation
3	5	10-5	6.73	0.32
3	5	10-7	6.73	0.38
3	5	10-9	6.79	0.31
3	5	10-12	6.64	0.27
3	5	10-29	6.39	0.14
3	5	11-4	6.46	0.18
3	6	10-5	6.21	0.37
3	6	10-7	5.80	0.33
3	6	10-9	6.09	0.26
3	6	10-12	5.94	0.37
3	6	10-29	5.53	0.32
3	6	11-4	5.74	0.35
4	7	10-5	4.89	0.45
4	7	10-7	4.85	0.31
4	7	10-9	4.78	0.35
4	7	10-12	4.79	0.27
4	7	10-30	4.55	0.21
4	7	11-4	4.51	0.19
4	8	10-5	5.60	0.26
4	8	10-7	5.28	0.29
4	8	10-9	5.46	0.21
4	8	10-12	4.98	0.49
4	8	10-30	5.26	0.30
4	8	11-4	5.41	0.17
5	9	10-5	7.06	0.37
5	9	10-7	7.06	0.31

Flat	Station	Sampling Date	Sediment Depth (inches)	Standard Deviation
5	9	10-9	6.96	0.31
5	9	10-12	7.16	0.21
5	9	10-30	6.91	0.24
5	9	11-4	6.71	0.29
5	10	10-5	5.61	0.22
5	10	10-7	5.39	0.35
5	10	10-9	5.26	0.22
5	10	10-12	5.43	0.35
5	10	10-30	5.30	0.23
5	10	11-4	5.00	0.38

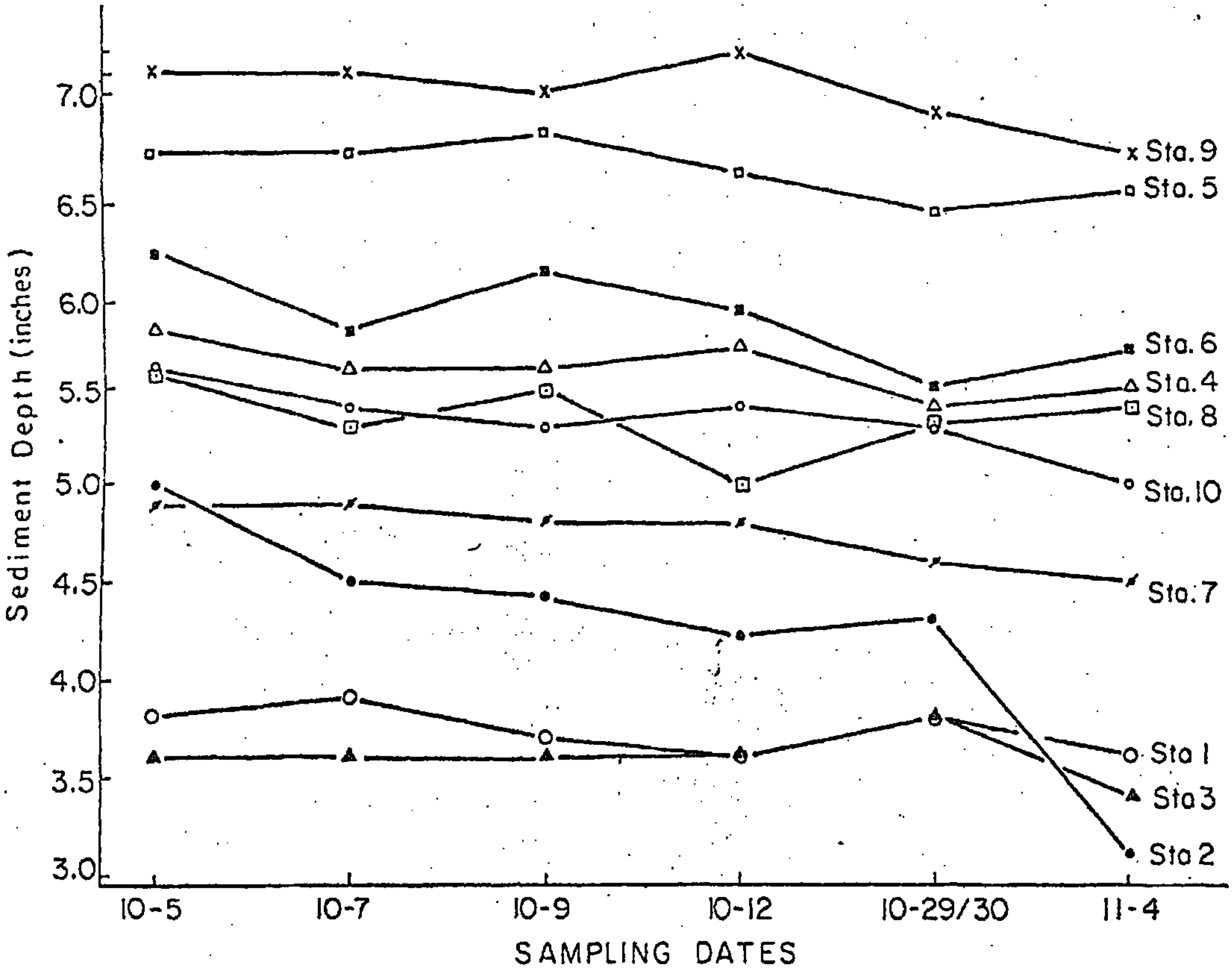

Fig. 2. Changes in sediment depth at each station over the course of the study. For station locations see fig. 1.

erosional and depositional cycles, changes in run-off and storms. The sediment depth data, therefore, shows that the dredging and disposal operations did not increase sedimentation of the flats.

Comparison of the grain size data also provided no evidence of disposition of dredge disposal on the clam flats (Table 2). The mean grain size of the sample of dredged material (.85 ϕ) was not in the range of sediments from the flats (1.92 to 6.17 ϕ). Furthermore, the dredged material was well sorted; only station 2, from the sand flat, was as well sorted. The skewness, which measures the degree of asymmetry of grain size distribution, shows that the dredged material was skewed toward coarser materials while the clam flat sediments were skewed toward finer materials.

DISCUSSION

Deposition of sediments is a complex function of waves, currents, tides and characteristics of source material. Relatively high energy input, produced by run-off, wind and tides, keeps larger particles in suspension, whereas smaller particles settle out at lower energy levels. Mud flats, by definition, are sedimentary structures made up of small particles and generally occur along low energy shores in protected inlets and estuaries. Therefore, the processes which form the flats preclude the deposition of coarse materials which settle out before they reach the backwaters of the mud flat. The results of the study support the conclusion that the dumping of a limited amount (53,278 cubic yards) of coarse grained sediments at the disposal site did not affect the ongoing processes of deposition on downstream mud flats sampled. It is

Table 2. Sediment type, sorting and skewness for Kennebec River estuary samples.

Flat	Station	Sampling date	Sediment type (from mean)	Sorting	Skewness
1	1	10-5	very fine sand	poorly sorted	near symmetrical
1	1	10-7	very fine sand	poorly sorted	near symmetrical
1	1	10-9	very fine sand	poorly sorted	near symmetrical
1	1	10-12	very fine sand	poorly sorted	near symmetrical
1	1	10-29	very fine sand	poorly sorted	near symmetrical
1	1	11-4	very fine sand	poorly sorted	near symmetrical
1	1	10-5	medium sand	moderately well sorted	fine-skewed
1	2	10-7	fine sand	moderately well sorted	near symmetrical
1	2	10-9	medium sand	moderately well sorted	near symmetrical
1	2	10-12	fine sand	moderately well sorted	near symmetrical
1	2	10-29	medium sand	moderately well sorted	near symmetrical
1	2	11-4	medium sand	well sorted	fine-skewed
2	3	10-5	very fine sand	poorly sorted	fine-skewed
2	3	10-7	coarse silt	poorly sorted	strongly fine-skewed
2	3	10-9	coarse silt	poorly sorted	strongly fine-skewed
2	3	10-12	medium silt	very poorly sorted	strongly fine-skewed
2	3	10-29	very fine sand	poorly sorted	strongly fine-skewed
2	3	11-4	coarse silt	poorly sorted	fine-skewed
2	4	10-5	very fine sand	poorly sorted	strongly fine-skewed
2	4	10-7	very fine sand	poorly sorted	strongly fine-skewed
2	4	10-9	very fine sand	poorly sorted	strongly fine-skewed
2	4	10-12	very fine sand	poorly sorted	strongly fine-skewed
2	4	10-29	very fine sand	poorly sorted	strongly fine-skewed
2	4	11-4	very fine sand	moderately sorted	fine-skewed
3	5	10-5	medium silt	poorly sorted	strongly fine-skewed

		Sampling	Sediment type		
Flat	Station	date	(from mean)	Sorting	Skewness
3	5	10-7	medium silt	poorly sorted	strongly fine-skewed
3	5	10-9	medium silt	poorly sorted	strongly fine-skewed
3	5	10-12	coarse silt	poorly sorted	strongly fine-skewed
3	5	10-29	medium silt	poorly sorted	strongly fine-skewed
3	5	11-4	medium silt	poorly sorted	strongly fine-skewed
3	6	10-5	medium silt	poorly sorted	strongly fine-skewed
3	6	10-7	medium silt	poorly sorted	strongly fine-skewed
3	6	10-9	medium silt	poorly sorted	fine-skewed
3	6	10-12	medium silt	poorly sorted	strongly fine-skewed
3	6	10-29	medium silt	very poorly sorted	strongly fine-skewed
3	6	11-4	medium silt	poorly sorted	strongly fine-skewed
4	7	10-5	medium silt	poorly sorted	strongly fine-skewed
4	7	10-7	medium silt	poorly sorted	strongly fine-skewed
4	7	10-9	medium silt	poorly sorted	strongly fine-skewed
4	7	10-12	medium silt	very poorly sorted	strongly fine-skewed
4	7	10-30	medium silt	poorly sorted	strongly fine-skewed
4	7	11-4	medium silt	very poorly sorted	strongly fine-skewed
4	8	10-5	coarse silt	poorly sorted	fine-skewed
4	8	10-7	coarse silt	poorly sorted	fine-skewed
4	8	10-9	coarse silt	poorly sorted	fine-skewed
4	8	10-12	coarse silt	poorly sorted	strongly fine-skewed
4	8	10-30	coarse silt	poorly sorted	fine-skewed
4	8	11-4	coarse silt	poorly sorted	strongly fine-skewed
5	9	10-5	fine silt	poorly sorted	strongly fine-skewed
5	9	10-7	fine silt	poorly sorted	fine-skewed

Flat	Station	Sampling date	Sediment type (from mean)	Sorting	Skewness
5	9	10-9	fine silt	poorly sorted	strongly fine-skewed
5	9	10-12	fine silt	very poorly sorted	fine-skewed
5	9	10-30	fine silt	poorly sorted	strongly fine-skewed
5	9	11-4	fine silt	poorly sorted	fine-skewed
5	10	10-5	medium silt	very poorly sorted	fine-skewed
5	10	10-7	medium silt	poorly sorted	strongly fine-skewed
5	10	10-9	medium silt	poorly sorted	strongly fine-skewed
5	10	10-12	medium silt	very poorly sorted	strongly fine-skewed
5	10	10-30	medium silt	poorly sorted	strongly fine-skewed
5	10	11-4	medium silt	poorly sorted	strongly fine-skewed
sample of dredged material			coarse sand	moderately well sorted	coarse-skewed

not possible, however, to draw the conclusion that the dumping of finer sediments or of a much greater volume of coarse sediments would also have little or no effect.

While the study did not focus on the fate of dredged material dumped at the disposal site, it is apparent from the hydrodynamic features of the disposal site that the newly deposited material is scoured away. The rate of scour from the dumpsite, and the point and time of subsequent deposition of the material are unknown, but it seems likely from the results of this study that coarser grained sedimentary structures, such as Popham Beach or offshore sand bars, and not the clam flats, may be receiving the sediment.

While the sampling design proved to be accurate and consistent in detecting changes in sediment depth, and was appropriate for this limited study, a more comprehensive program would be needed to assess the effect of dredging and disposal operations in general on the naturally operating sediment transport regime in the Kennebec estuary. A thorough understanding of this regime would be a sound basis for predicting the effects of different types of dredging projects involving a range of spoil amount and type.

Such a study might incorporate the following aspects: 1) more frequent sampling over a longer period of time to determine naturally occurring variation in sediment, 2) determination of upstream sediment input, 3) subtidal sampling, 4) sampling of a control estuary, 5) labelling of spoils with radioactive isotopes or dyes, and subsequent downstream sampling to detect the pathways and ultimate deposition of spoils, 6) determination of the lethal dose of sediment for clams.

Results of a comprehensive study would enlighten decision making on Kennebec estuary dredging projects. It is likely, for example, that a point in the annual sediment cycle could be determined as the most appropriate time for dredging and disposal. Information could be provided which would be useful not only in protecting the estuarine environment but also in predicting the life span of the dredged channel.

LITERATURE CITED

Folk, R.L. 1968. Petrology of sedimentary rocks. Hemphill's, Austin, TX. 170 p.