PILOT STUDIES FOR THE RESTORATION OF *Spartina alterniflora* BEDS IN GREAT BAY ESTUARY

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Abstract

This report discusses *Spartina alterniflora* transplant efforts in the Great Bay Estuarine system. Five sites were chosen that represented a cross-section of intertidal soft substrata found in the Great Bay area. Each site was planted in May 1983 with plugs of marshgrass from nearby marshes. The *Spartina alterniflora* transplants were monitored monthly for growth (plant length) and density (shoot development). Replanting occurred when plants were washed out of the substratum. Grain size analysis (mechanical) was conducted on sediments at each site for correlation with plant survival. Transplant efforts at three sites were unproductive as plants were washed from the substratum, while the two remaining sites exhibited strong growth through the summer and produced healthy shoots in the fall. Thus, large scale *Spartina* replanting can be successful at appropriate sediment types in the estuary. More elaborate techniques of transplanting are needed for heavily oiled areas and moderate energy locations.

Introduction

Saltmarshes occur along estuaries and embayments in the intertidal zone of low to moderate energy shorelines. The marsh dimensions may vary due to the extent of suitable substratum within the intertidal zone. Marsh systems were broadly distributed along Atlantic, Gulf and Pacific coasts before impact by man. Extensive areas of coastal marshlands have been lost to commercial and industrial development. Since 1850, in California alone, an estimated 1,000 square kilometers of wetlands have been diked and filled (U.S. Army Engineer District, San Francisco, 1976).

The importance of coastal marshes has been demonstrated repeatedly in the past two decades. They act as nursery grounds for a large number of commercial and recreational fishery species (Odum, 1961; Teal and Teal, 1969; Williams and Murdock, 1969) and they serve as energy sources for the detrital based food web of coastal ecosystems (Odum, 1961). Tidal marshes are also important as storehouses for minerals and nutrients, as they trap and collect nutrients from estuarine waters and transfer them to coastal waters (Williams & Murdock, 1969). The ability to mitigate coastal storm damage by absorbing the flood waters of storm tides and to reduce erosion of headlands makes saltmarshes valuable in developed shoreline areas. In New Hampshire's Great Bay Estuarine system alone there are 837.5 acres of marshlands which are valued at 68 million dollars annually because of their production values to the ecosystem (NH Fish and Game Department, 1981).

The Spartina beds in Great Bay estuary have shown decreases in standing crop at various locations and concern for the beds has led to discussion of restoration attempts. There has been no previous transplantation studies of S. alterniflora in New Hampshire either by direct seeding or plug (sprig) transplants. A marsh building program was initiated in North Carolina in 1969 under the sponsorship of the Coastal Engineering Research Center (CERC) (Woodhouse, 1979; Woodhouse et al, 1972, 1974). The latter work has primarily dealt with the transplantation of S. alterniflora into dredge spoils from channel dredging projects. Since then, transplant attempts have been conducted in Chesapeake Bay (Garbisch et al, 1975) and on the Gulf coast (Dodd and Webb, 1975). Pacific coast marsh building was initiated in 1975 (Knutson, 1975; U.S. Army Engineer District, San Francisco, 1976; Knutson, 1977). The studies met with great success in a variety of situations. The present study was concerned with the feasibility of Spartina alterniflora transplants into certain areas of the Great Bay Estuarine system where pre-existing marshes have disappeared or been considerably reduced in size through a variety of factors.

Material and Methods

The transplant techniques utilized in this study required only a few basic tools. Long-handled spades, hand trowels and metal washtubs were used to gather Spartina alterniflora plugs from the edges of existing marshes near the site. A plug consists of the aerial portion of the plant, its leaves and stems and the underground rhizome mass. The plugs chosen usually consisted of 1-3 stems and an adequate amount of attached rhizome. Plugs were loosened from the edges of tidepools or marshes. The plugs were removed in mid May when S. alterniflora growth had begun to accelerate (plants averaged 20 cm. in height). Plugs were obtained from marshes in the general area (usually within 50 yards of the transplant site). The Rollins Farm site contained one row of plants that originated from Bunker Creek on the Oyster River approximately 3.0 miles upstream from the transplant site.

Five transplant sites were chosen at four areas that utilized barren stretches of mudflat or peat beds near pre-existing saltmarshes (Figure 1). The areas (Rollins Farm, Varney Creek, Boston Harbor and Fox Point) were chosen to reflect the different soil types and beds of saltmarshes.

During May, Spartina alterniflora plugs with substantial rhizomes were placed into appropriate sized holes in the substratum and the sediment firmed around each plug. Although fertilizer has been successfully used in the South, it was

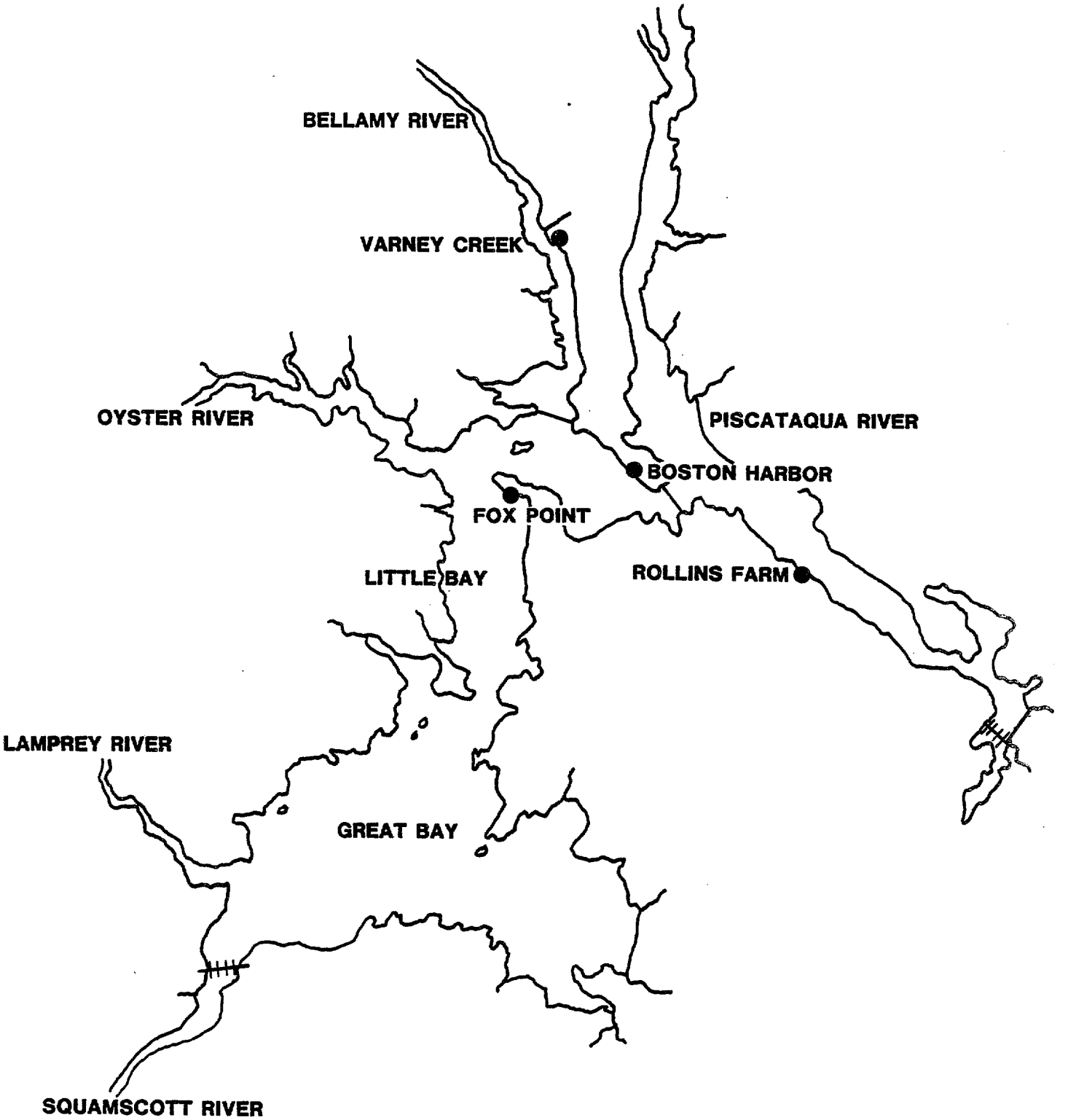


Figure 1. Saltmarsh Restoration Sites in Great Bay Estuary

not used in this study due to the availability of nutrients in the estuarine water (Loder et al, 1979). The spacing of transplants was 18 inches at Rollins Farm, Varney Creek and Boston Harbor, while Fox Point plants were spaced at one-foot intervals. Initial height measurements were taken of all plants, in addition to counts of the number of stems and shoots (emerging growth). Monthly observations of plant growth were subsequently made during the remainder of the growing season (Table 1). Grain size analysis (mechanical) of the soils, was performed by N.H. Fish and Game Department personnel using the facilities of the N.H. Department of Public Works and Highways Testing Laboratory. Sediment grain size was determined by sieving each sample through various sized screens ranging from 4.75 mm to 0.075 mm.

TABLE 1. Saltmarsh Sampling Schedule from May - October, 1983

Station	May	June	July	Aug.	Sept.	Oct.
Boston Harbor	x	x	x	x	x	x
Rollins Farm	x	x	x	x	x	x
Varney Creek	x	x	x	x	x	x
Fox Point	x	x	x	x	x	x

Results and Discussion

Site Characterization

Results of sediment analyses are presented in Figure 2. The Rollins Farm site on the Piscataqua River had a sand-mud substrata reflecting the influence of strong tidal currents. Boston Harbor, further upstream in Little Bay, exhibited clay-sand substrata with an eroding saltmarsh scarp directly behind it. A second site at Boston Harbor, or the "peat site", was located upon the marsh scarp in a dense peat area, that had no current Spartina alterniflora growth. No sediment samples were taken here because of the high fiber content. Fox Point is a broad, sandy point that juts into Little Bay forcing tidal currents to bend around the promontory. Sediments here were predominately sand and pebbles. The Varney Creek site, an area well protected from strong currents and wave action, was located close to the mouth of the creek where it empties into the Bellamy River. Soils here tended to be highly organic in nature with a preponderance of detrital particles and river-borne silts involved in the sediment composition.

Stem Density

In general, where plants remained intact (Varney Creek and Fox Point), stem

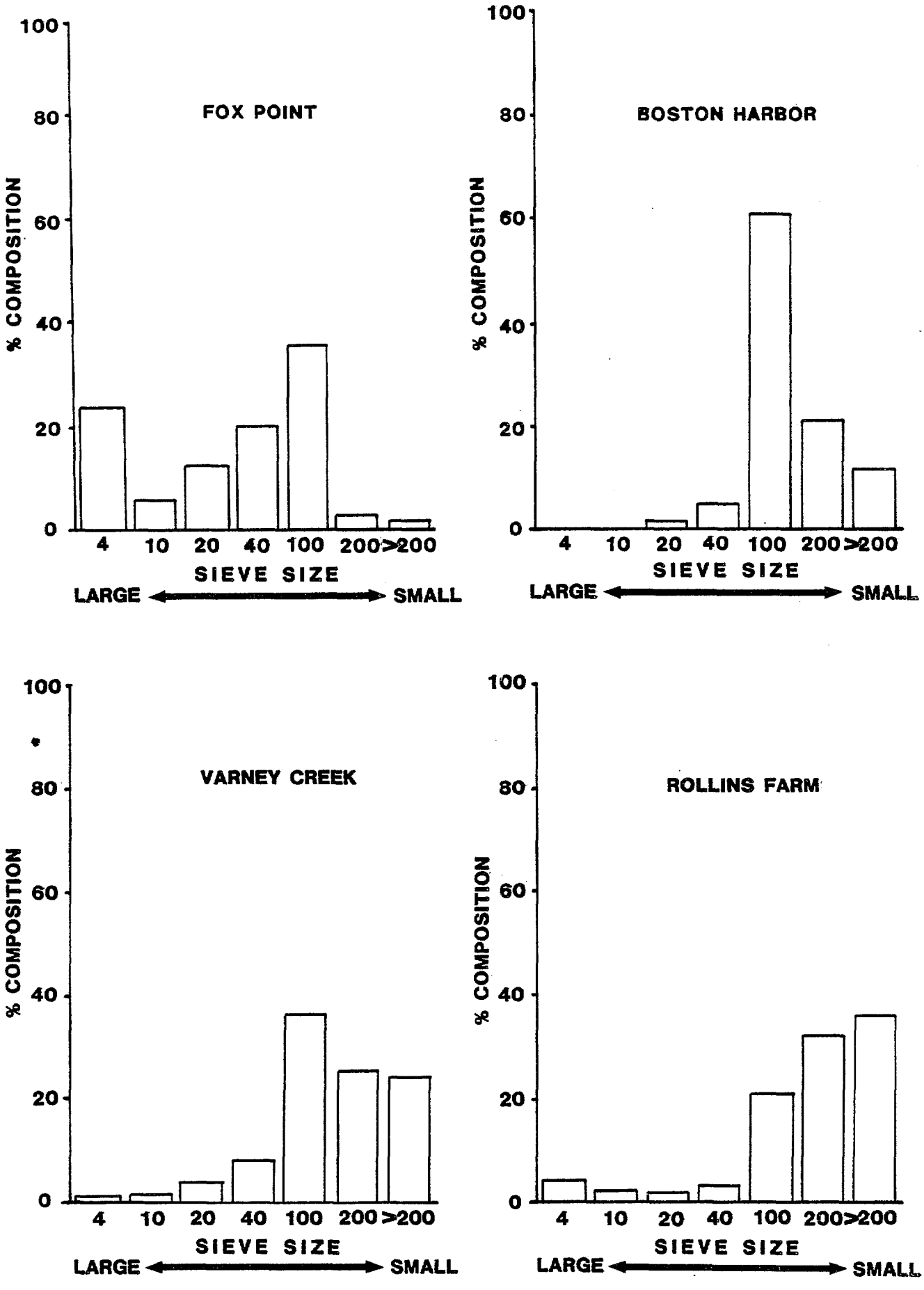


Figure 2. Results of Grain Size Analyses for Spartina alterniflora Transplanting Sites

densities increased through August (Table 2). There was a slight decrease in September followed by increased stem densities in October, due to a proliferation of new shoot growth. The renewed shoot growth in October is characteristic of S. alterniflora in the Great Bay estuarine system (N.H. Fish and Game Department, 1981).

Average stem densities at Varney Creek increased to a high in August when they ranged from 1.8 to 2.2 stems per plug (Table 2). Varney Creek experienced an overall decline in September, but increased in October to 1.9 to 2.8 average stems per plug, reflecting increased growth of late season shoots. The Fox Point site exhibited steady growth and increase in stem numbers through August, when densities ranged from 2.5 - 3.7 stems per plug (Table 2). The only decline in stem density occurred in September, as mature plants were broken off and removed by tides.

The Boston Harbor and Rollins Farm sites gradually showed reduced stem densities as plants were washed out of the substratum at these sites (Table 2). Rollins Farm lost all of its plants during August, while Boston Harbor lost the majority of its plants in the June-July period. A replanting effort was conducted at Rollins Farm in August, but these plants were removed by natural sources (waves, tides) within 1 - 2 months.

Boston Harbor had two transplant areas: one on the intertidal mudflat near a drainage ditch; the other was located on the eroded marsh scarp in a denuded peat bed. Plants washed out of the sediment sooner at the former site than the latter area (Table 2). Thus, the peat site still contained a number of plants in August, long after the plants had been washed from the mudflat area. Grain size graphs showed that sediments at the Boston Harbor mudflat site were primarily small in nature (Figure 2). Growth was observed for a short period at both locations of Boston Harbor, before the plants were washed from the sediment.

Rollins Farm exhibited decreases in average stem numbers during the two month period, i.e. when the plants were still intact. Grain size analysis revealed the sediment at Rollins Farm contained the greatest amount of small particles of all stations tested (Figure 2). The small particle size combined with the area's long fetch, probably had deleterious effects upon the plants in this area. The second transplant effort at Rollins Farm also disappeared in less than 2 months.

TABLE 2. Monthly Mean Number of Stems per Transplanted Plugs of *Spartina alterniflora* at Great Bay Estuarine Study Sites

Transplant Location	Row #	May	June	July	Aug	Sept.	Oct.
Varney Creek	1	1	1	← WASHED OUT →			
	2	1	1	1	2.2	1.4	1.9
	3	1.2	1.2	1.1	2.2	2.0	2.8
	4	1.2	1.0	1.0	2.1	1.9	2.5
	5	1.6	1.4	1.2	1.8	2.0	2.2
Boston Harbor Mudflat	1	1.5	1.4	← WASHED OUT →			
	2	1.5	1.5	← WASHED OUT →			
	3	2.3	3.0	← WASHED OUT →			
Peat Area	1	1.7	2.4	2.0	1.9	← WASHED OUT →	
	2	1.7	1.6	2.0	← WASHED OUT →		
	3	2.3	1.9	1.0	← WASHED OUT →		
Fox Point	1	1.4	1.4	2.6	2.5	2.2	2.2
	2	1.7	1.5	2.2	2.7	2.0	3.0
	3	1.7	1.8	2.7	3.6	2.7	3.0
	4	1.6	1.6	2.3	3.7	2.3	3.8
Rollins Farm	1	3.2	2.2	3.4	1.7*	1.0	WASHED OUT
	2	4.9	4.3	2.2	← WASHED OUT →		
	3	3.3	2.4	1.5	← WASHED OUT →		

* New Planting

Stem Height

Initial stem heights for transplanted Spartina alterniflora were recorded in May, 1983 at the four study sites (Table 3). The heights ranged from 13.8 cm at Boston Harbor to 42.1 cm at Varney Creek (Figure 3). The disparity in stem heights resulted from the various locations of the transplant sources. Varney Creek, located upstream on the narrow Bellamy River, is an example of a relatively young marsh, where plant rhizomes have not become densely intertwined. Since it is located inland from the main body of the estuary, it warms rapidly in the spring, thus initiating plant growth earlier in the season. Boston Harbor is located directly on Little Bay with a considerable expanse of tidal water forming its seaward boundary (Figure 1). It is a much older marsh, as evidenced by its high eroding marsh scarp and firm substratum, due to the thick rhizomal growth of S. alterniflora and S. patens. Boston Harbor also exhibited a dwarf form of S. alterniflora in comparison with the tall form found at Varney Creek (N.H. Fish and Game Department, 1981). Thus, the initial height of S. alterniflora reflected the location, conditions and types of plants found in certain areas of the estuary. Initial stem heights of 16.1 - 21.6 cm were recorded at Rollins Farm. The larger plants originated from Bunker Creek marshes. Rollins Farm was the only site to receive plants from a distant location.

Substantial plant growth occurred in June at all four sites (Figure 3, Table 3). Growth was most pronounced at Varney Creek where heights averaged 47.6 - 60.0 cm for the five rows of plants. Rollins Farm exhibited strong growth in rows 2 and 3 where heights average 39.8 cm and 30.4 cm respectively (Figure 3). Stem growth at Fox Point and Boston Harbor was moderate during the first month. By July, all plants at the Boston Harbor mudflat had washed out. The remaining plants located in the peat area had mixed growth values (Figure 3, Table 3).The top row of plants nearest mean high water (MHW) at Varney Creek was washed away during June and July. The lower 4 rows, however, showed growth with heights of 69.2 - 75.4 cm. The transplants at Fox Point exhibited steady growth through July, with stem height averaging 23.0 - 28.0 cm. Transplants at Rollins Farm decreased in height and numbers during the June-July period. By August all of the original transplants at Rollins Farm were lost. Replanting of S. alterniflora at this site was not successful as the plants were removed by natural forces within 2 months (Table 3).

Varney Creek showed a slight decrease in stem height during August but increased again in September before the loss of adult plant growth in October, the

TABLE 3. Monthly Mean Height (cm) of Spartina alterniflora Transplants at Grest Bay Estuarine Study Sites

Transplant Location	Row#	May	June	July	Aug.	Sept.	Oct.
Varney Creek	1	42.1	0.0*	← WASHED	OUT →		
	2	36.0	49.5	75.0	68.0	74.3	50.3
	3	39.7	48.2	69.2	67.6	71.4	48.8
	4	37.6	51.1	75.4	68.8	76.3	37.5
	5	37.8	47.6	69.6	72.2	78.4	53.0
Boston Harbor Mudflat	1	28.9	29.1	← WASHED	OUT →		
	2	29.2	38.3	← WASHED	OUT →		
	3	18.3	26.0	← WASHED	OUT →		
Peat Area	1	15.0	17.6	19.4	0.0*	← WASHED OUT →	
	2	18.8	23.4	19.5	← WASHED OUT →		
	3	13.8	17.1	17.0	← WASHED OUT →		
Fox Point	1	19.3	23.9	28.0	27.9	28.9	15.3
	2	14.8	20.4	23.0	23.5	24.1	22.3
	3	14.1	19.1	24.3	39.4	29.4	18.8
	4	15.8	19.9	23.9	24.5	25.6	18.8
Rollins Farm	1	21.6	24.4	29.1	62.0**	75.2	WASHED OUT
	2	16.1	39.8	10.7	← WASHED OUT →		
	3	17.5	30.4	11.0	← WASHED OUT →		

* Only shoots present - too short to measure

** Second planting

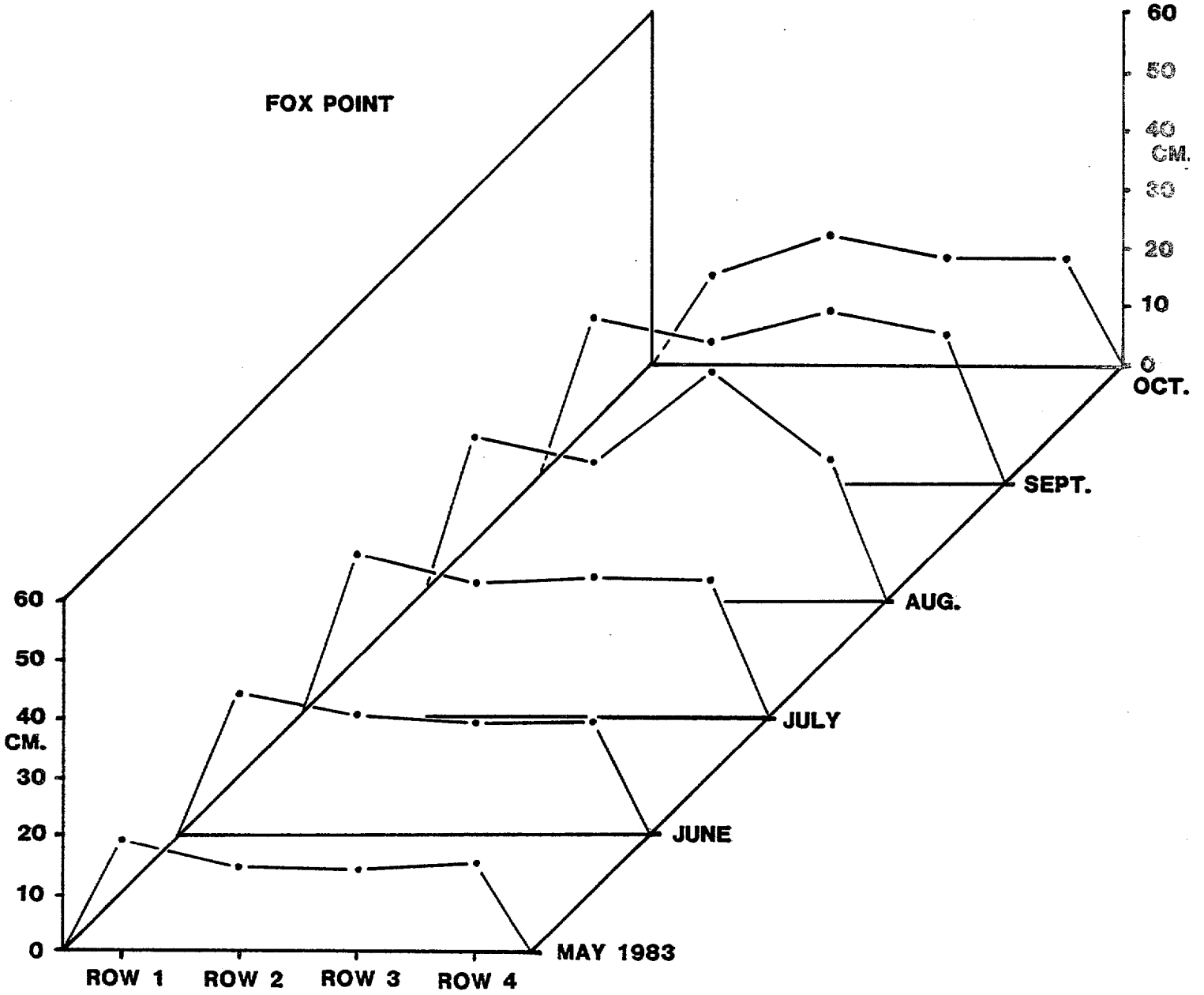


Figure 3. Seasonal Growth (Mean Stem Height) of Spartina alterniflora Transplants at Fox Point, Varney Creek, Boston Harbor, and Rollins Farm

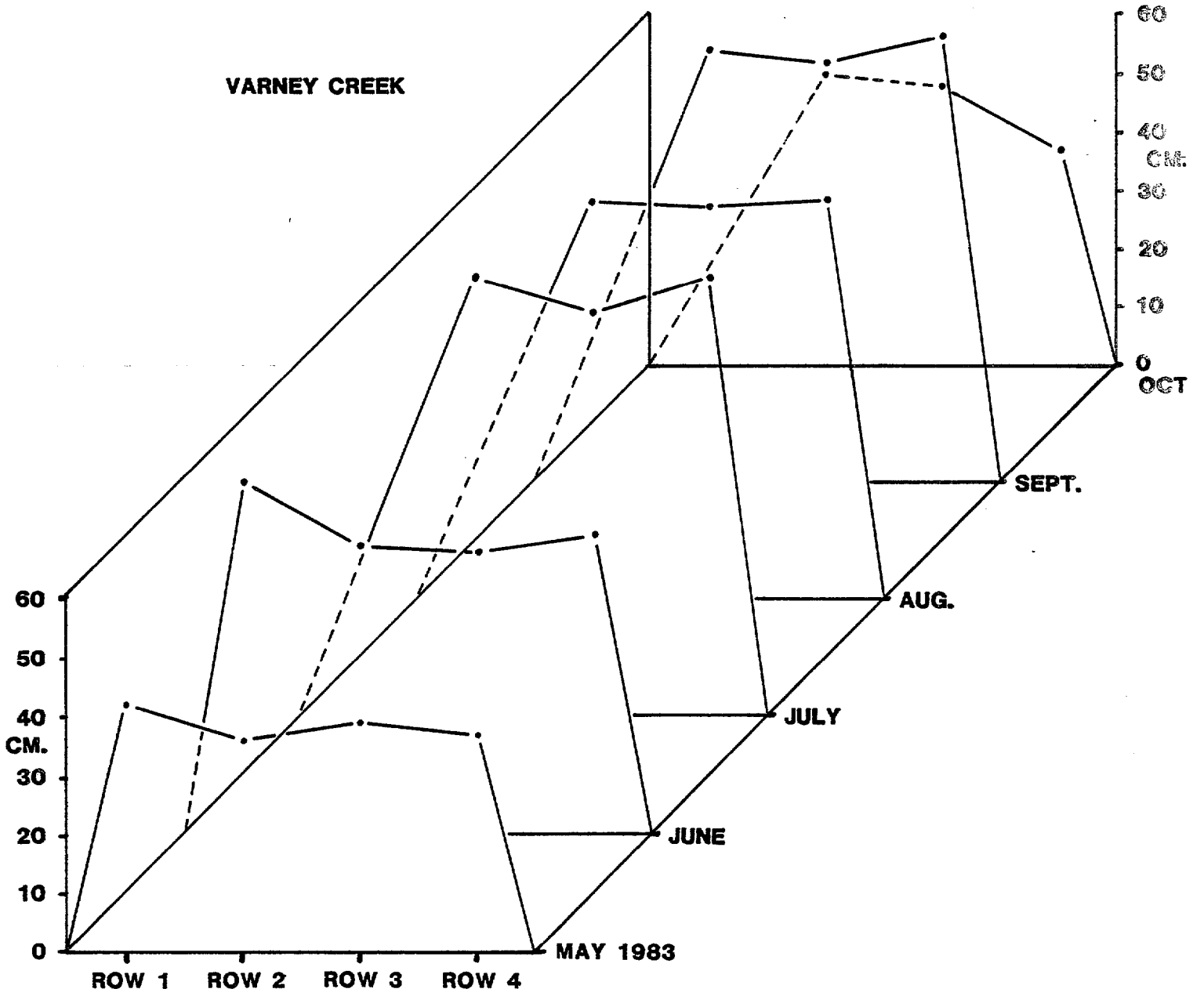
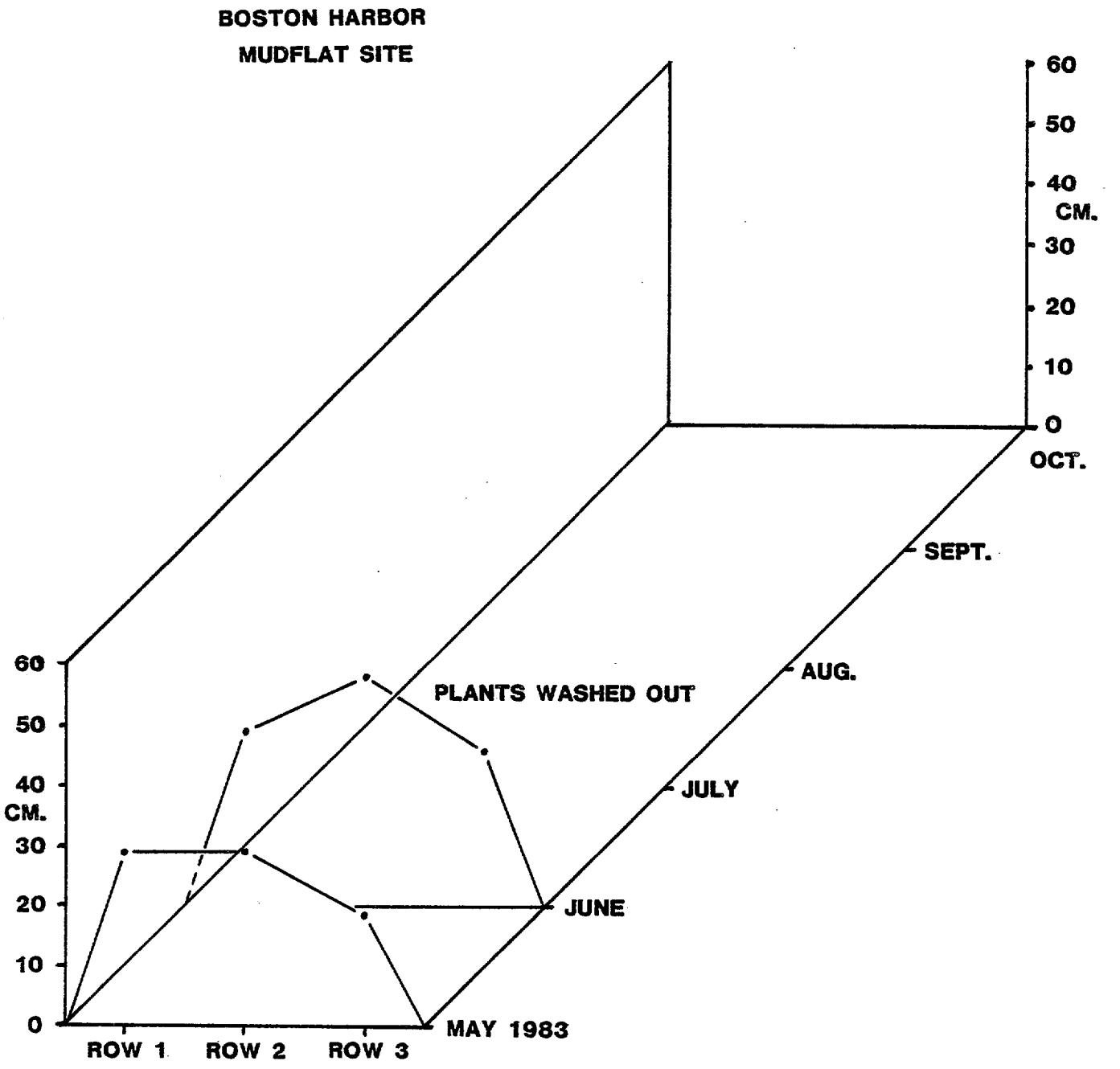


Figure 3 (con't)



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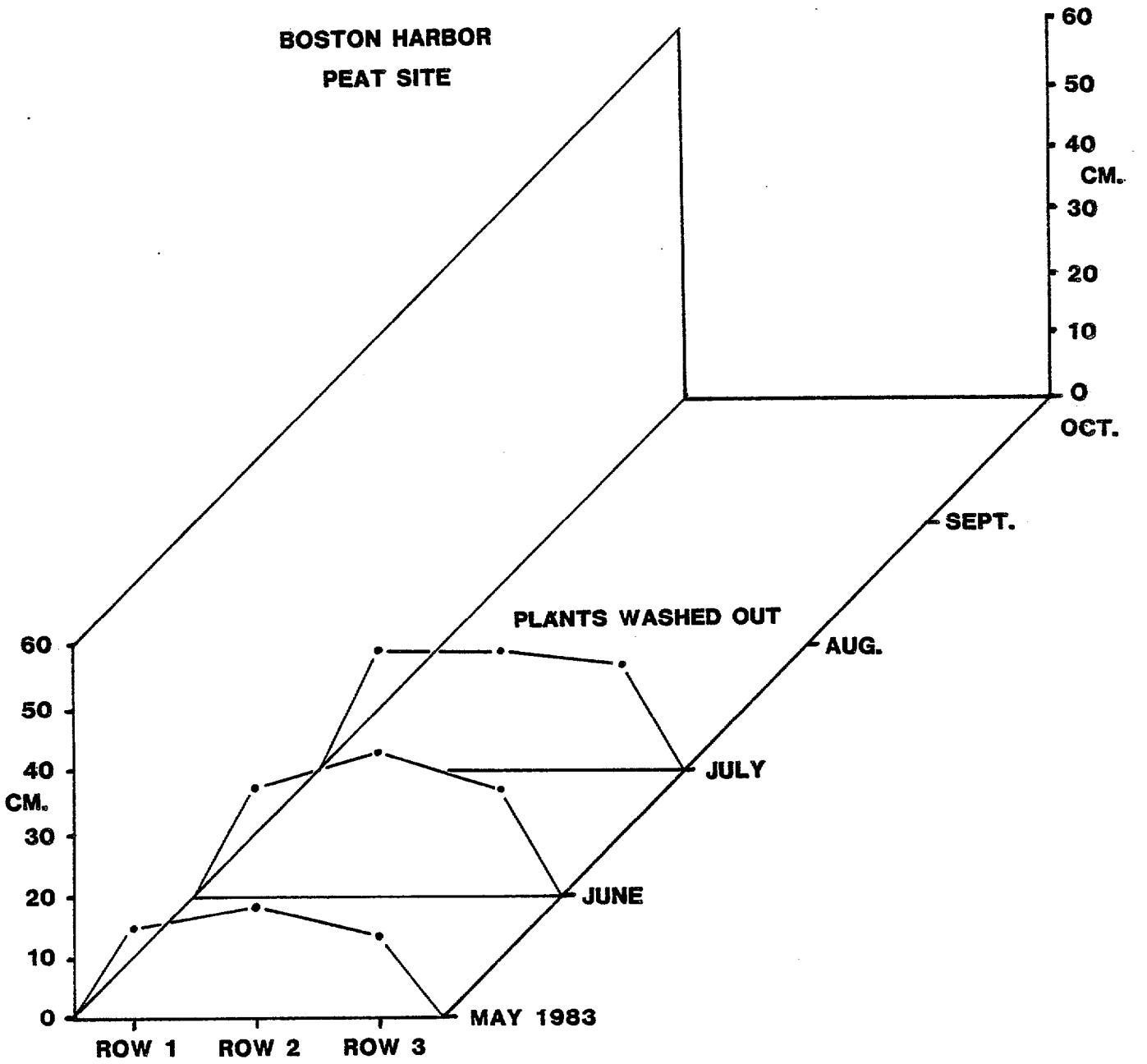

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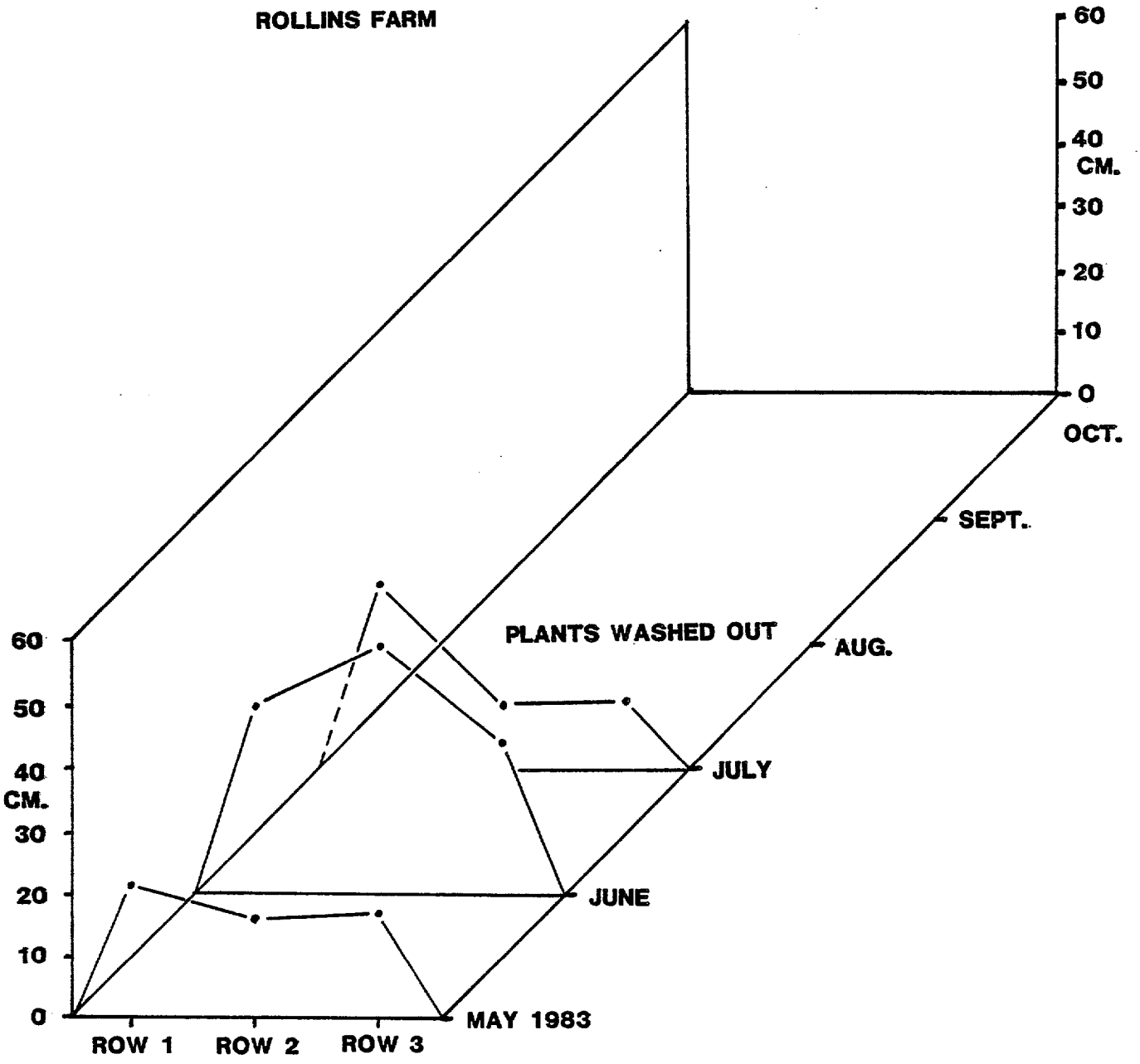

Figure 3 (con't)

end of the growing season in Great Bay. At the Boston Harbor peat site, only 12 of the original plants were left by August. These plants were small shoots with no large stems. The transplants at Fox Point exhibited little or no increase in stem height during the remainder of the period August-October (Figure 3). However, by the end of October, the transplants at Fox Point had the highest number of intact plants of any site (Figure 4). Sediment grain size at Fox Point consisted primarily of large sand particles. During the August period, a thin sedimentary precipitate washed over the sandy substratum and formed a firm cover over the tranpslanted area. This cover, accompanied by the large grain size of the sandy substratum, perhaps kept the majority of the transplants intact.

Conclusion and Recommendations

Varney Creek exhibited the maximum growth of transplants, in terms of stem heights, even though over 60% of the transplants were lost. Highly organic, fertile conditions, and a well protected area were probably responsible for the strong growth recorded there. Boston Harbor with its exposed location and preponderance of minute sediment particles proved to be unfavorable for Spartina alterniflora transplants. Boston Harbor has been heavily impacted by oil spills and oil was observed on the surface of the peat bed during this study. The fact that transplants in the peat site of Boston Harbor were not successful raises the possibility of continued impact by hydrocarbon contamination. Fox Point was the most successful area for the survival of transplants. There, 63% of the original transplants remained firmly rooted and healthy in appearance at the end of October. Plants in this area grew slowly but steadily. Rollins Farm, with its large fetch on the Piscataqua River and strong tidal currents, was a difficult area for successful establishment of transplants.

It would be our recommendation that wide scale Spartina replanting be conducted in appropriate sediment types throughout the estuary. Analysis of hydrocarbon content in Boston Harbor peat beds coupled with laboratory research on the effects of these concentrations on Spartina plants will determine if the continued deterioration of the beds and resistance to transplanting are a result of oil spills. It is further recommended that other techniques of transplanting be tried in areas subjected to strong tidal currents and long fetches. The techniques could include fertilization of transplants, use of larger plugs (3-6 stems) and physically anchoring the plugs.

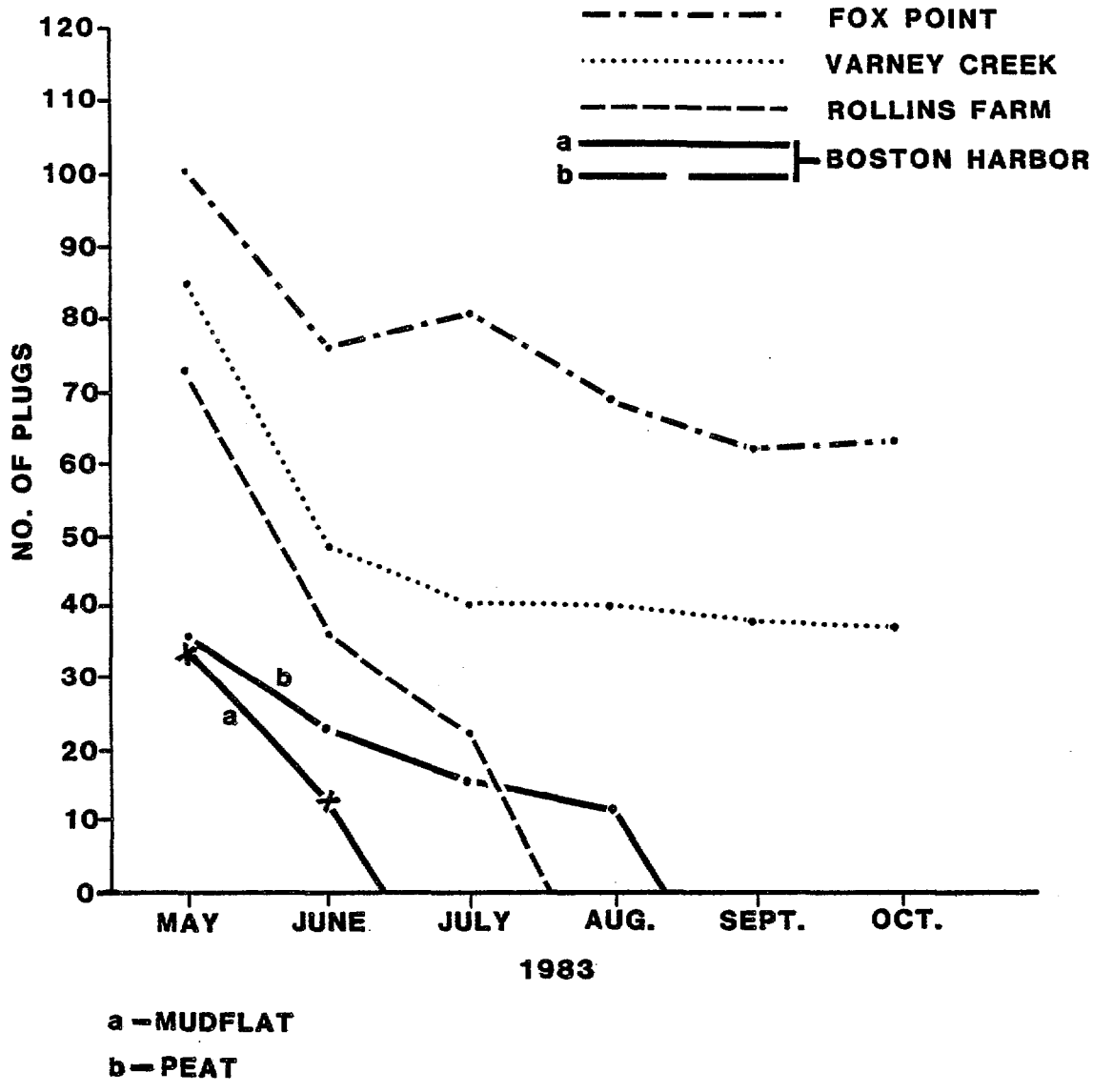

Figure 4. Survival of Spartina alterniflora Transplants in Great Bay Estuary

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