

# Depth-Area-Volume Relationships in Narragansett Bay



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# Depth-Area-Volume Relationships in Narragansett Bay

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The cover figure is a three-dimensional view of Narragansett Bay, Rhode Island, with transect 11 as the southern border (see Figure 10). The land surface is shown in dark green, with the bottom topography in blue. The computer-generated figure was drawn using the G3D procedure in SAS/GRAPH.

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## INTRODUCTION

In spite of the fact that Narragansett Bay is among the most frequently studied bodies of coastal marine water in the world, no detailed hypsographic analysis of the system has yet been published. As part of his description of the basic physical oceanography of the area, Steacy D. Hicks (1959) provided a depth-area-volume curve for the bay as a whole, but the increasing intensity of research and management efforts involving the bay requires a more detailed and extensive treatment.

The lack of a hypsographic atlas is a common handicap for those studying bays, lagoons, and estuaries around the world, though it may come as a surprise to those in social sciences and management that such basic physical information is absent or inadequate (Capper, Power, and Shivers, 1983). The reason for the deficiency is that the compilation of hypsographic information by traditional interpolation and planimetry is extremely tedious. However, it is possible to bring together certain of the computer mapping and graphics programs presently available to develop a relatively simple, rapid, highly flexible, and inexpensive analysis of bathymetric or topographic data.

This publication reports the results of such an analysis for Narragansett Bay, including bathymetric contour charts, the area, volume, mean depth, and shoreline length for various subregions of the bay, cross-sectional areas in a number of places along the bay, the bathymetric profiles of transects along the passages of the bay, and the cumulative volume of the bay as a function of increasing distance from various points. After a description of the methods used in the analysis, the results are grouped in the order just described and presented in graphical and tabular form.

Although the boundaries we have chosen for Narragansett Bay are shown in Figure 1, it may be helpful to provide a narrative description as well. The northern limit is taken as the Rt. I-195 bridge across the combined Woonasquatucket-Moshassuck Rivers and across the Seekonk River. The Providence River extends into the Pawtucket River on the west as far as the first dam. The Warren River is included up to the Rt. 103 bridge. In Mount Hope Bay, the Kickamuit River is taken as extending up to Laurel Park, the embayments of the Cole and Lee Rivers up to their respective barrier spits and beaches, and the Taunton River up to the Rt. I-195 bridge. The Sakonnet River extends from the Hummocks to a line from Sakonnet Point to Sachuest Point. The seaward limit of the East Passage of Narragansett Bay is defined by a line from Brenton Point to Beavertail Point, and the West Pas-

sage by a line from Beavertail Point on a heading of 284° true to a small unidentified point on the shore of Boston Neck, about halfway between Bonnet Point and the Narrow River inlet.

In a more detailed analysis of the Seekonk River and the Providence River (Figure 3), the northern limit of the Seekonk is set at the Blackstone River dam at Pawtucket and its southern limit is fixed at the Rt. I-195 highway bridge. The Providence River extends from that bridge to a line connecting Nayatt Point and Conimicut Point.

There is no well-established definition of the boundaries of Narragansett Bay (Pilson, 1985), and it is likely that some will find good reason to take exception to those we have used here. Some of our decisions were arbitrary; others were influenced by geography or engineering.

# METHODS AND PROCEDURES

## A. Overview

The technique for deriving a computer-generated hypsographic analysis of Narragansett Bay involved three major steps:

1. digitization of the locations and depths associated with published U.S. National Ocean Survey bathymetry stations
2. transformation of the bathymetry stations from an irregularly spaced distribution to a uniform, regularly spaced grid
3. conversion of the resultant grid to charts, graphs, cross-sectional views, and summary tables and graphs

## B. Digitization

Using data from the Coast and Geodetic Survey (NOAA-NOS Chart #13221, scale 1:40,000, surveys performed between 1943 and 1957; see Table 1) with revised data from the Army Corps of Engineers (1979), some 4,500 shoreline points and the location and depth of approximately 4,000 irregularly spaced bathymetry stations from Narragansett Bay were digitized with a Science Accessories Corporation Graf/Pen sonic digitizer, Model GP6-50. Each bathymetry station was assigned a depth value (to the nearest 0.1 meter) referenced to mean low water (MLW), and an x-y coordinate (to the nearest 0.5 millimeter). On average, there were 12 bathymetry stations for every km<sup>2</sup> on the source map.

Table 1. Hydrographic survey history.

Element	Survey Date(s)
1	1956
2	1956
3	1956
4	1944 and 1956
5	1944 and 1956 and 1957
6	1957
7	1943 and 1949
8	1956 and 1957
9	1955 and 1957
10	1957

From: George Mastioganis, NOS Hydrographic Survey Branch, personal communication, annotated chart, dated March 1, 1985.

Since there is tidal variation around MLW, a table of tidal ranges is provided in Table 2. When multiplied by bay area, these values give an estimate of water volume changes through a mean tide cycle (see Table 5). We have also provided a table that compares a portion of the Hicks hypsographic analysis (1959) to our results (see Table 3). We do this not to make any claims as to the correct values, but simply to show the similarity in the results. Our estimate of the total area of Narragansett Bay proper plus Mount Hope Bay is about 35 km<sup>2</sup> smaller than that given by Pilson (1985). Virtually all of this can be attributed to his inclusion of the Taunton, Palmer, and Barrington Rivers.

## C. Transformation

Transformation of the irregularly spaced digitized data to a uniform grid of depth values was accomplished using URISYMAP (Program URISYMAP, 1984), a version of SYMAP (SYMAP, 1975).

In general, SYMAP transforms irregularly spaced data points from a source map into a uniform, regularly spaced grid by interpolating among the observed data values. The interpolated data values are weighted averages of the observed data points, with the weighting based on the inverse square of the distance from the observed points. The resulting grid of observed and interpolated points is composed of individual cells of unit area.

The shoreline locations on the source map were used as the boundary of the digitized area (A-OUTLINE of SYMAP), and as additional bathymetry stations by assigning to them a depth of 0 meters. The x-y coordinate and depth values for each bathymetry station were entered in the B-DATA and E-VALUES sections, respectively, with impermeable barriers designated (in the D-BARRIERS section) at prominent peninsulas and islands to prevent interpolation through the land mass. Several critical SYMAP electives (in the F-MAP section) were effected to produce an output map with a 1:1 relationship to the source map (Elective 13) and an output of the interpolated grid (Elective 21) in which each depth value was computed independently for every cell (Elective 37).

Output from SYMAP provided the information required for calculating the dimensions of an individual cell in the grid. Obviously, these dimensions were in the same units as the source map. However, by applying the map scale to the cell dimensions,

the real world area encompassed by the cell was ascertained; in this case each cell was a rectangle 101.6 meters wide and 127.0 meters long.

At this point in the procedure a grid with about 26,000 cells had been produced; each cell was associated with a depth value and occupied a unit area on the floor of the bay.

**Table 2.** Tide ranges based on a ten-year numerical model for Newport, R.I. Through 7,100 simulated tidal cycles, the tide range varied from 0.49 to 1.83 m (mean = 1.08 m, s.d. = 0.27 m). The spring and neap tide ranges (for Newport, R.I.) were arbitrarily designated as the mean range plus and minus 1 s.d., respectively (see figure below; M. Spaulding, personal communication). Correction factors determined in the model were applied to formulate the tide ranges in each of the ten elements.

Element	Neap Tide Range (m)	Mean Tide Range (m)	Spring Tide Range (m)
1	0.94	1.25	1.55
2	0.91	1.22	1.52
3	0.91	1.22	1.52
4	0.88	1.16	1.46
5	0.82	1.07	1.34
6	0.91	1.19	1.49
7	0.85	1.13	1.40
8	0.82	1.07	1.34
9	0.91	1.22	1.52
10	0.82	1.07	1.34

From: Swanson and Spaulding (1977, 1984).

#### D. Conversion

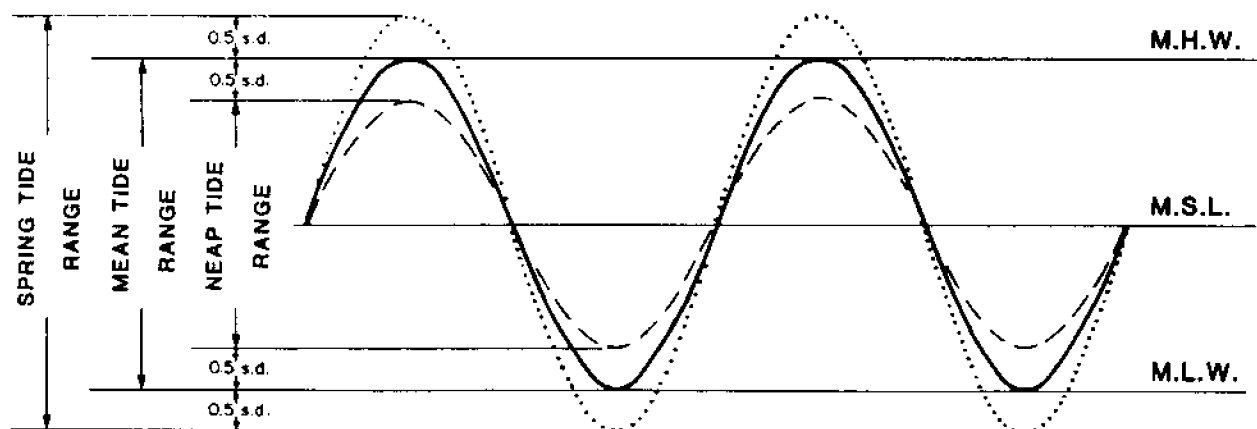
Use of the computer for data handling allowed a flexibility not otherwise possible. Graphical and tabular representations of the data were developed for the bay as a whole, and for portions of the bay, by assigning each cell in the grid to one of ten distinct spatial elements and to one of 41 latitudinal segments (Figure 1). The ten spatial elements within the bay were chosen on the basis of geography and with the intention of making them similar to those in the Narragansett Bay ecosystem model (Kremer and Nixon, 1978). Some cells were also designated as parts of a transect.

Depth, area, volume, and x-y coordinate values were associated with, and uniquely defined, each

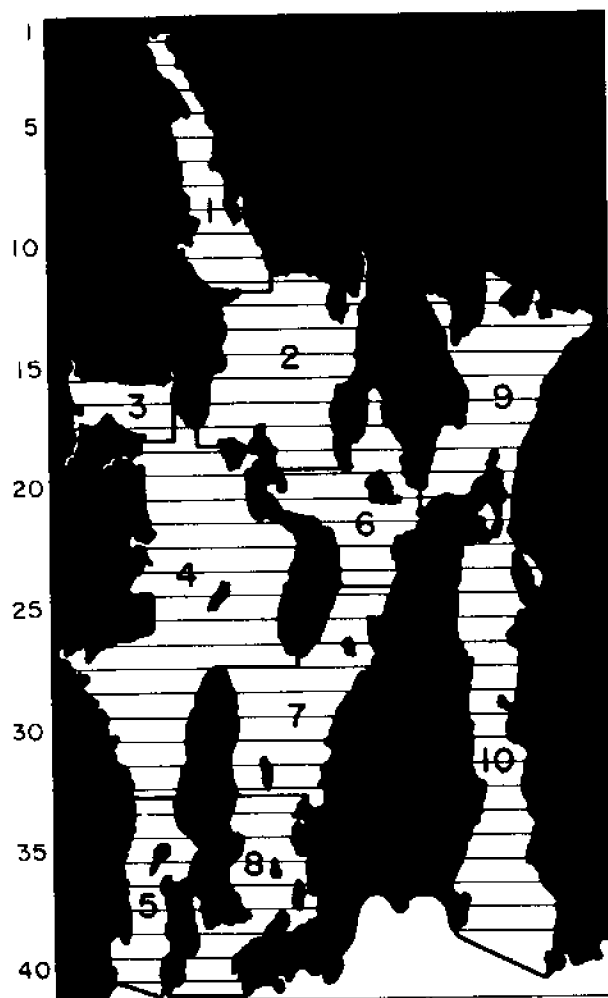
**Table 3.** Comparison of the results of this study with an earlier hypsographic analysis by Hicks (1959).

Depth <sup>1</sup> (m)	Area Below Depth (km <sup>2</sup> )		Volume Below Depth (m <sup>3</sup> × 10 <sup>6</sup> )	
	Hicks	This study	Hicks	This study
0	325	342	2832	2673
9.1	93	103	793	680
18.3	28	24	283	203
27.4	9	10	85	62
36.6	3	2	18	9
42.7	0.5	0.6	3	2

<sup>1</sup>The irregular metric depths result from the conversion of equivalent English units used in the Hicks study (1959).



cell in the grid. Volume, being the product of the cell unit area and depth, was that amount of water above the floor of the bay within the individual cell. Using these values, depth-area-volume relationships were developed with the aid of a computer program. The schematic components of our hypsographic analysis are shown for a cross-section of an

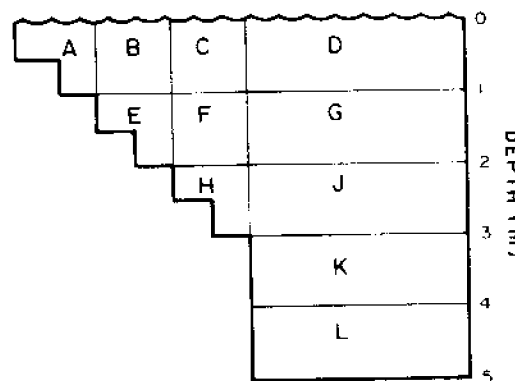


**Figure 1.** Narragansett Bay elements and segments. (Element 1, Providence River; Element 2, Upper Bay; Element 3, Greenwich Bay; Element 4, Upper West Passage; Element 5, Lower West Passage; Element 6, Upper East Passage; Element 7, Middle East Passage; Element 8, Lower East Passage; Element 9, Mount Hope Bay; Element 10, Sakonnet River.) Boundaries between the numbered spatial elements are shown in heavy lines. Latitudinal segments are delineated by light horizontal lines and are numbered along the left margin.

idealized bay in Figure 2. For simplicity, the schematic is divided into 0.5 meter depth intervals, but our analysis was performed on 0.1 meter intervals. Note that this bay has a dredged channel (as does Narragansett Bay) and that the sides and floor are perpendicular. We have also assumed the sides and floor of Narragansett Bay to be perpendicular. Based on this assumption, the value of the cell unit area represented only the projected bottom area and did not include any additional area due to the sloping bay floor. Nevertheless, there was less than 0.005% error in evaluating the mean bottom slope as a flat projection.

### Calculation of Areas

The area of the idealized bay (see Figure 2) with a bottom depth between 0 and 1 meter is the projected surface area of Box A. Likewise, the area of the bay with a bottom between 1 and 2 meters is the area of Box E, and so on. Any area associated with a specified depth or depth interval was similarly calculated. Thus, the area of the bay with a bottom deeper than 0 meters is the bottom area of the entire bay, A+E+H+L (equal to the area of A+B+C+D). The area of the bottom which is deeper than 1 meter includes the area of E+H+L. There is no bay floor between 3 and 4 meters; thus, this area = 0 m<sup>2</sup> and the area of the bay deeper than 3 meters is equal to that of the bay deeper than 4 meters. Area calculations were performed by counting the number of cells chosen by the depth selection criteria and multiplying the count by the unit area. An example of the grid of individual cells from which all area and volume estimates were made is shown in a detail of Bristol Harbor (Figure 4).



**Figure 2.** Idealized cross-section of bay showing hypsographic components.

### Calculation of Volumes

After calculating the area of the bay and various parts of the bay within each 1 meter depth interval, we proceeded to estimate the volume of water contained within each of the depth intervals. Such an exercise is not as simple as it may first appear, since multiplication of the area and depth information directly available in the computer yields only the volume of water above an area of specified depth. It would not include water within the depth interval that lay over a deeper floor. For example, in Figure 2 the volume of water in the 1-2 meter depth interval is the combined volumes of E+F+G, but the multiplication of the bottom area between 1-2 meters and depth (to the nearest 0.1 meter) gives the volume of B+E. The situation is further complicated by the large size of the data set.

The solution to this problem may best be explained by example. In the case of the 1-2 meter depth interval discussed above, the procedure was to take the area below 1 meter (= area of E+H+L), subtract the 1-2 meter depth interval area (E), and multiply the area of H+L by 1 meter to get the volume of F+G. The product of the area of the 1-2 meter depth interval and depth (in 0.1 meter increments) gave the volume of B+E. The volume of B is simply the area of the 1-2 meter depth increment multiplied by the depth of water lying on top of the interval (in this case 1 meter) and can easily be subtracted. The volume of E was then added to the volume of F+G to give the total volume of water between 1 and 2 meters. A special subroutine was developed to handle the situation where there was no bottom area in a given depth interval, as in Box K in Figure 2. Other solutions to the problem of volume calculation were possible, such as a subroutine to search for and recognize the part of a cell's volume that occurred in a particular interval, but such a solution would have required greater computer time and cost. Though our computer procedure is cumbersome to describe, it was fast and inexpensive to run.

Graphics were generated by the GCONTOUR and GPLOTT procedures in SAS/GRAPH (1981).

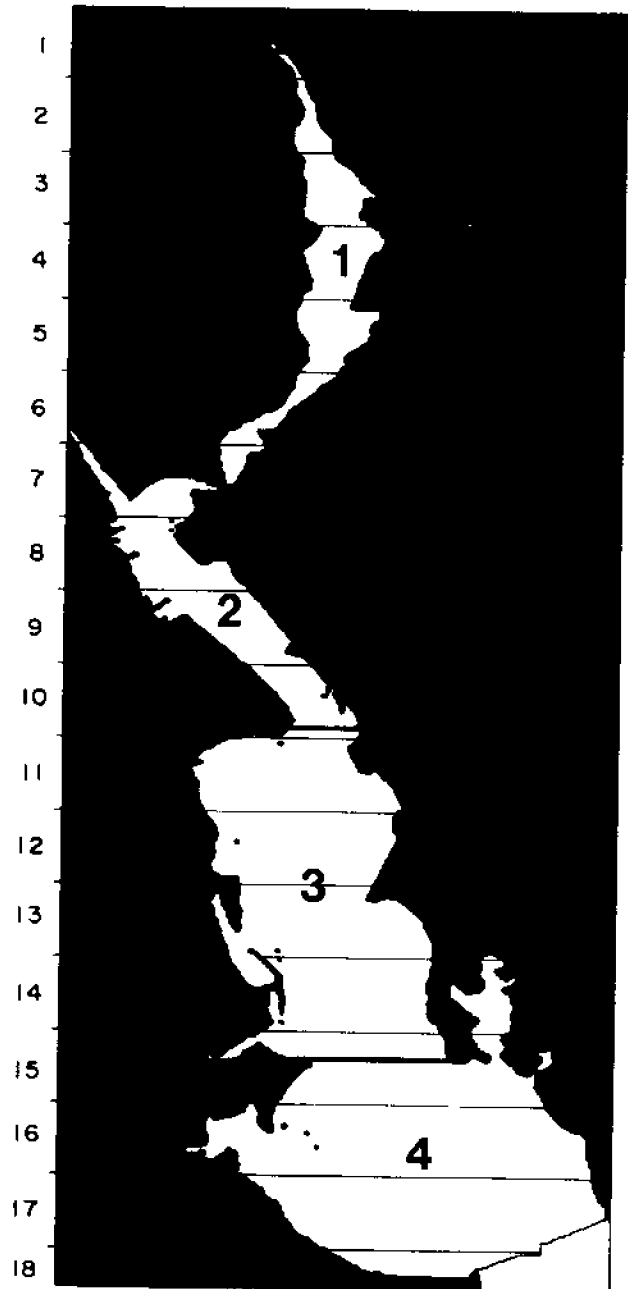


Figure 3. Detailed Seekonk and Providence River elements and segments. (Element 1, Seekonk River; Element 2, Fox Point Reach; Element 3, Sabin Point Reach; Element 4, Nyatt Point Reach.) Boundaries between the numbered spatial elements are shown in heavy lines. Latitudinal segments are delineated by light horizontal lines and are numbered along the left margin.



## RESULTS

### E. Modifications for a More Detailed Analysis of the Seekonk and Providence Rivers

Because the relatively small but heavily developed Seekonk and Providence Rivers are of special interest to many people, a second hypsographic analysis was performed on these areas (Element 1 in the general Narragansett Bay analysis plus the Seekonk, which was not included in the total bay calculations), using a finer scale source map (NOAA-NOS Chart #13224, scale 1:20,000) with more bathymetry stations (2,200 shoreline locations plus 900 bathymetry stations; see Figure 3). There were, on average, 37 bathymetry stations per km<sup>2</sup>. In addition, an increased SYMAP scale (Elective 13) was implemented which called for two units on the output map for every one unit on the source map. Recalculated volume results for the Providence River were expected to differ somewhat from those of the initial procedure, since a larger number of bathymetry stations (especially near the shoreline) was available. It was also interesting to see if the resolution of the initial procedure was fine enough (cell size 101.6 by 127.0 meters) to provide an area estimate that would not differ significantly from a re-analysis using a smaller cell size and, thus, higher resolution. The re-analysis was performed using a grid of approximately 30,000 cells, each cell 25.4 by 31.75 meters, with the ensuing cell density 16 times greater than in the original analysis.

In every other aspect, the Providence River re-analysis was performed identically to that of Narragansett Bay.

Using a computer to generate a hypsographic analysis of Narragansett Bay permitted the presentation of results in a variety of formats. The data are presented here as charts, graphs, tables, and cross-sections. Because it may be useful to have the same information presented in different degrees of detail, some results are presented in both graphical and tabular form. The results themselves are self-explanatory with the aid of figure and table legends.

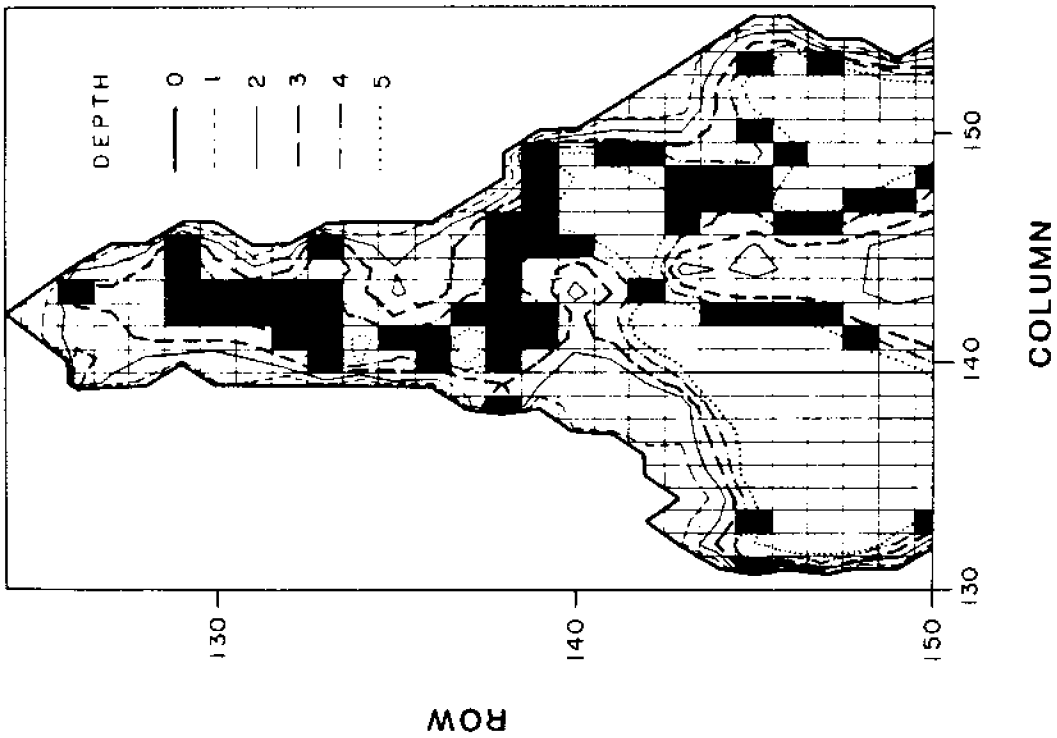
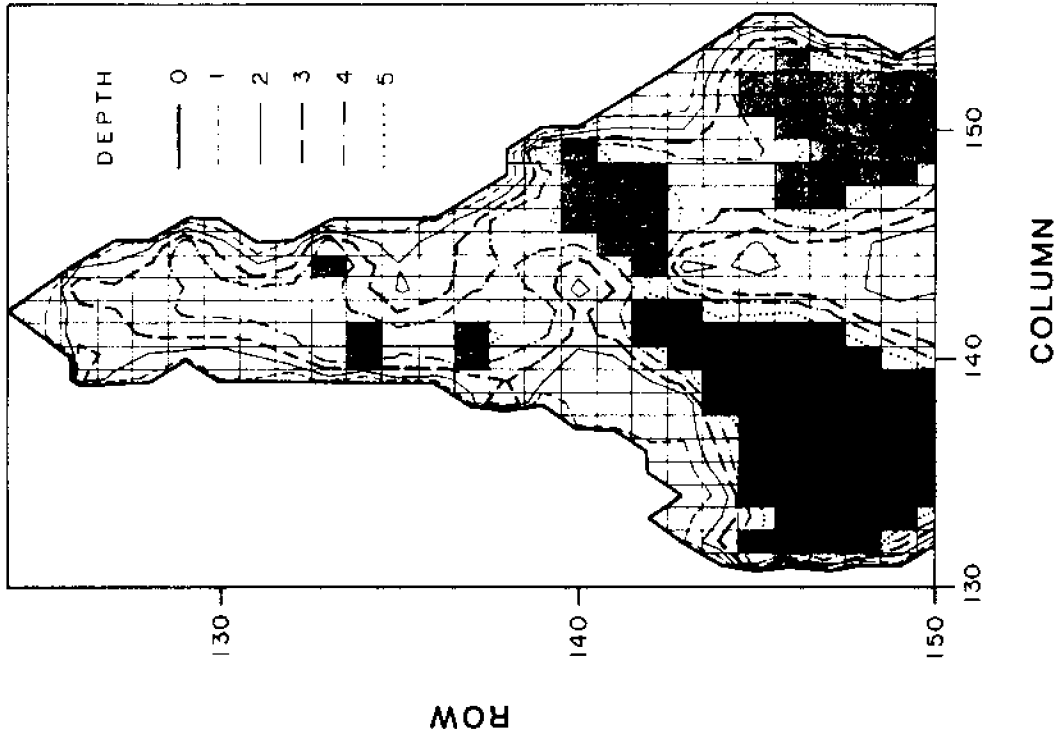


Figure 4. Bristol Harbor contour maps. Contour lines were drawn at 1 m depth increments by SAS/GRAPH. Superimposed on the contour map is the interpolated grid structure showing the individual cells. A comparison is made to contrast the cell technique for determining area and volume values with the mapping procedure which interpolates between cells to draw continuous contour lines. The map and two levels of cell values are shown above. Cells with depth values in the 4-5 m depth interval are shown shaded on the left, and cells with depth values greater than 5 m are shown shaded on the right.

Figure 5a. Narragansett Bay contour map.  
The 0-3 m depth interval is shown in blue.



Figure 5b. Narragansett Bay contour map.  
The 3-5 m depth interval is shown in blue.

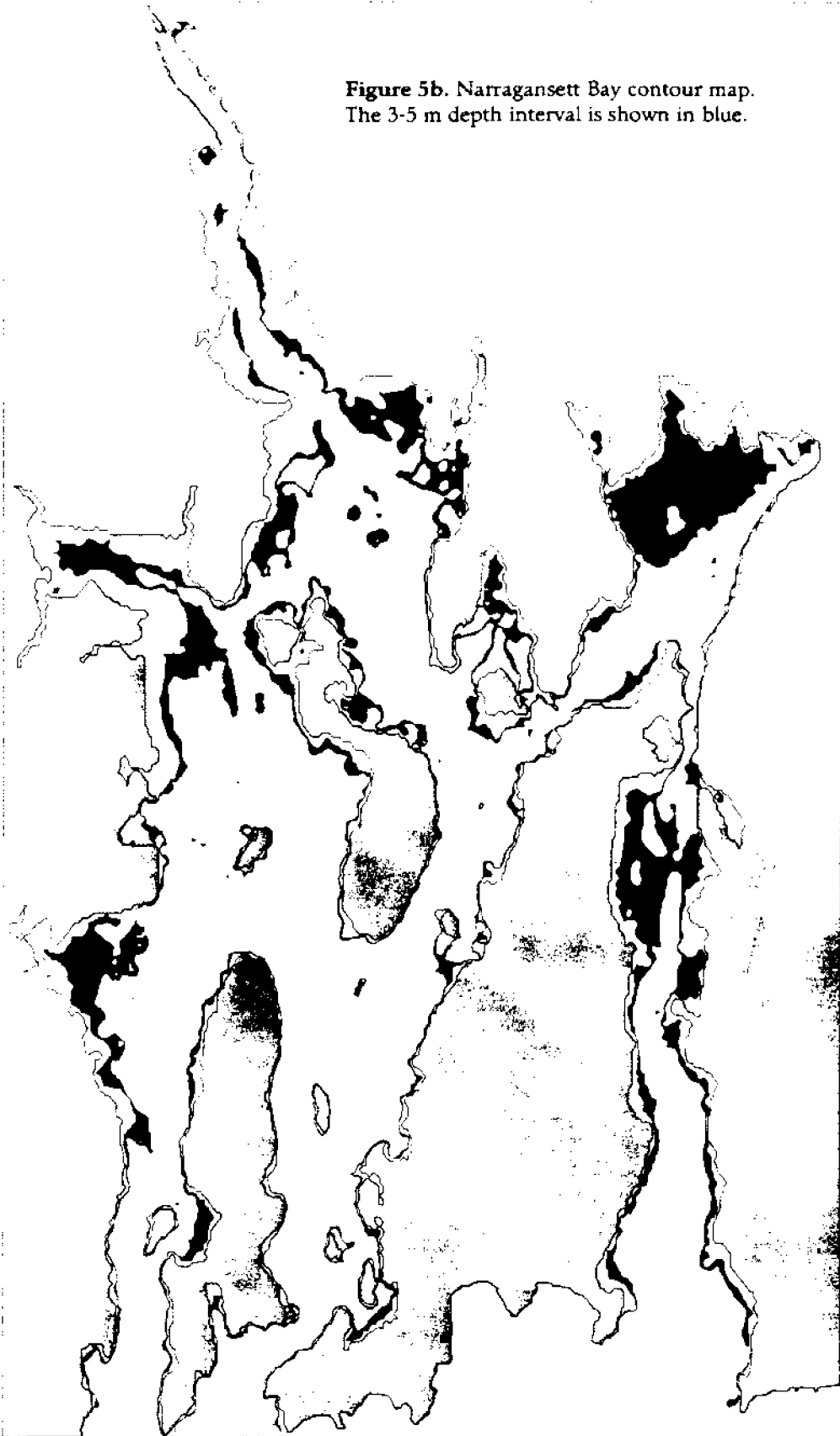


Figure 5c. Narragansett Bay contour map.  
The 5-10 m depth interval is shown in blue.



**Figure 5d. Narragansett Bay contour map.**  
The 10-20 m depth interval is shown in blue.

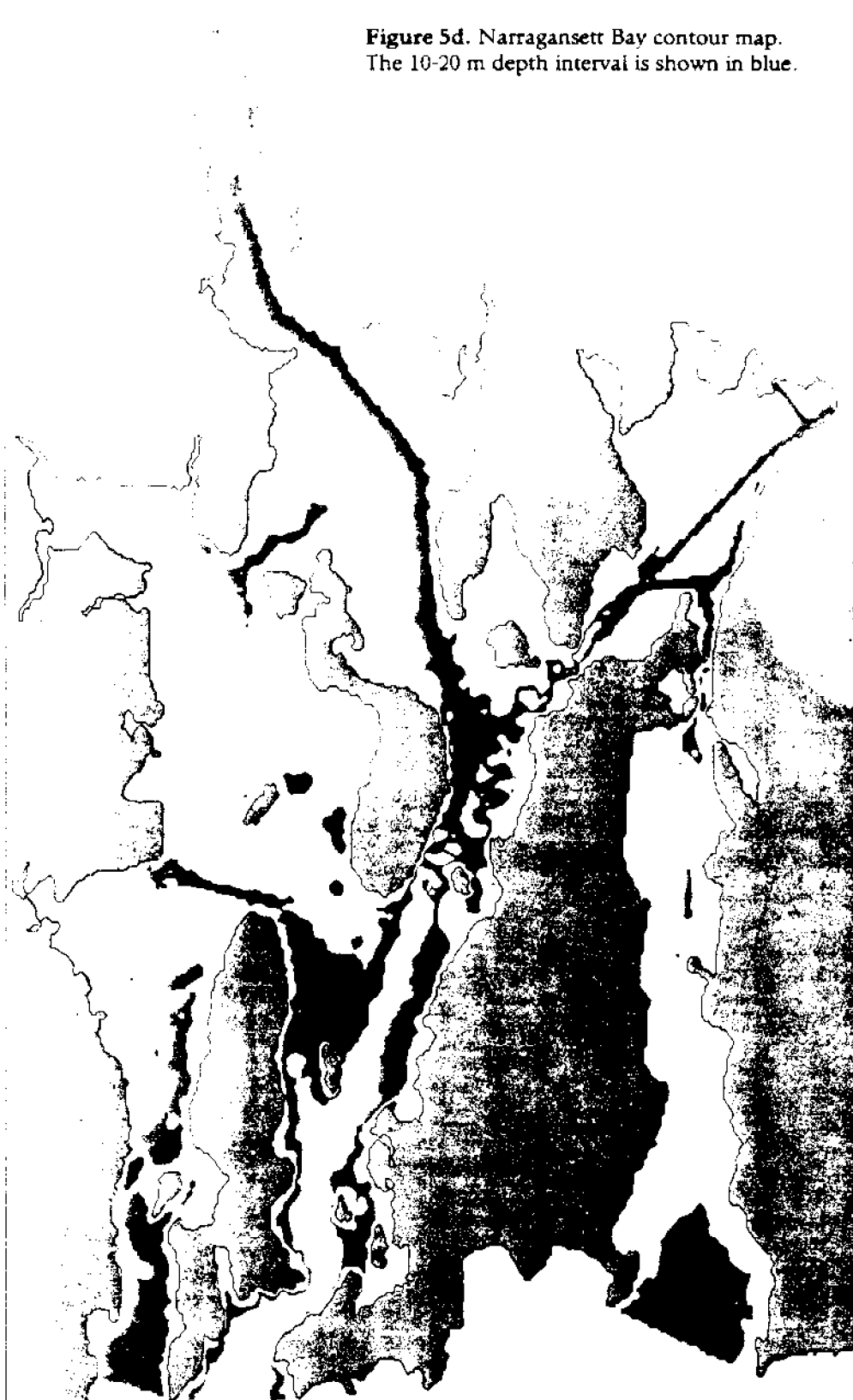
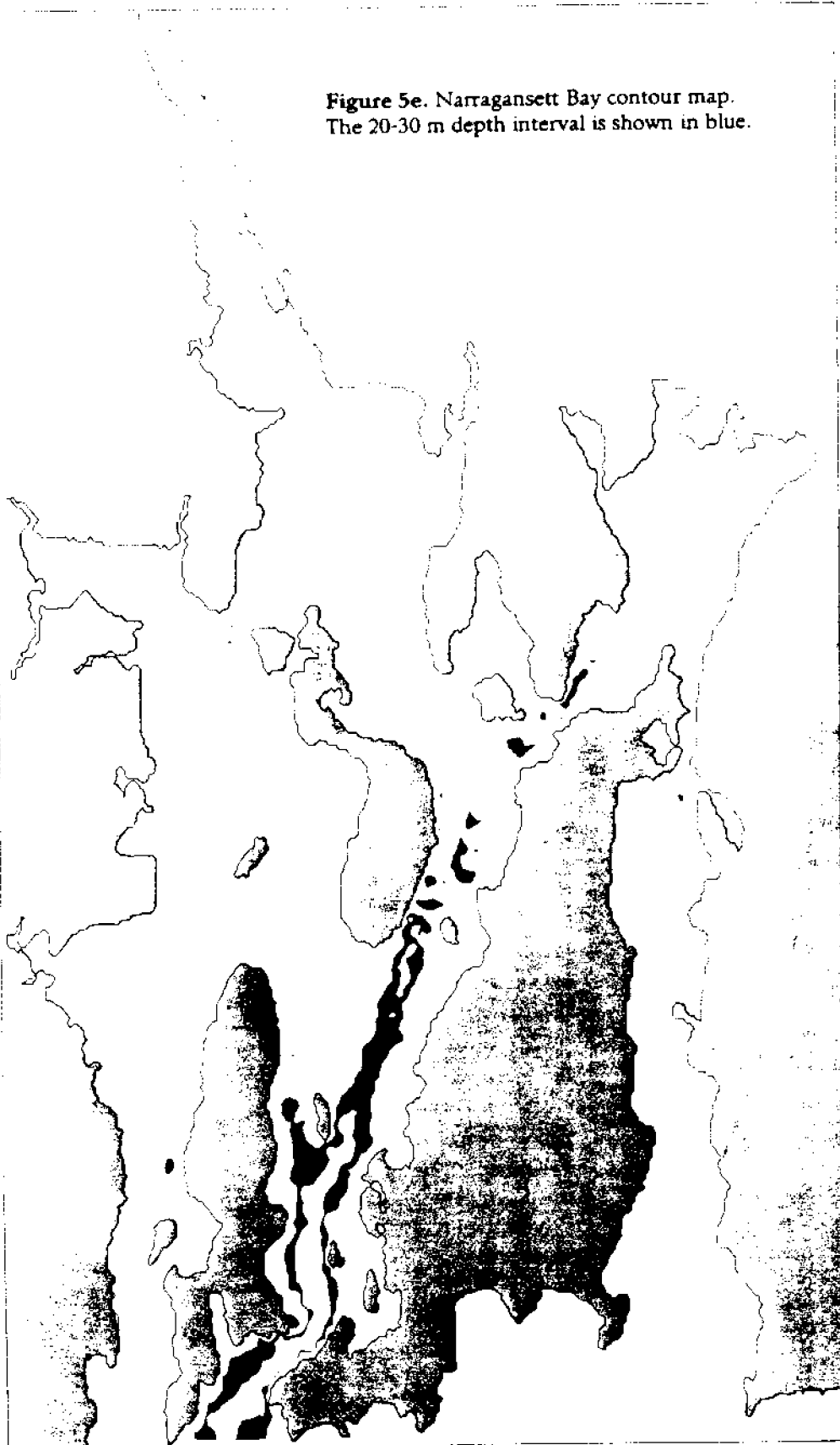


Figure 5e. Narragansett Bay contour map.  
The 20-30 m depth interval is shown in blue.



**Figure 5f.** Narragansett Bay contour map.  
The 30-40 m depth interval is shown in blue.  
The white area surrounded by the blue contour is deeper than 40 m.





Table 4. Summary of the total area and volume, mean depth, and shoreline length. Since the area and volume values are referenced to mean low water (MLW), we have provided another table (see Table 5) with the approximate volume of the elements under various tide conditions assuming constant area.

Geographical Region	Area (km <sup>2</sup> )	Volume (m <sup>3</sup> x10 <sup>9</sup> )	Mean Depth (m)	Shoreline Length (km)
<b>Total Bay Analysis<sup>1</sup></b>				
Narragansett Bay (Elements 1-10)	341.715	2673.080	7.82	412.5
Narragansett Bay, Excluding Mt. Hope Bay and Sakonnet River (Elements 1-8)	255.548	2139.847	8.37	299.5
West Passage (Elements 4-5)	95.858	634.703	6.62	91.8
East Passage (Elements 6-8)	83.484	1128.288	13.52	104.6
Providence River (Element 1)	21.277	110.935	5.21	42.2
Upper Bay (Element 2)	43.290	241.323	5.57	33.7
Greenwich Bay (Element 3)	11.639	24.599	2.11	27.1
Upper West Passage (Element 4)	77.922	474.534	6.09	63.6
Lower West Passage (Element 5)	17.935	160.169	8.93	28.2
Upper East Passage (Element 6)	23.806	174.551	7.33	30.9
Middle East Passage (Element 7)	34.335	479.391	13.96	28.7
Lower East Passage (Element 8)	25.342	474.342	18.72	45.0
Mount Hope Bay (Element 9)	35.200	201.699	5.73	46.2
Sakonnet River (Element 10)	50.968	331.537	6.50	66.8
<b>Detailed Analysis of Providence and Seekonk Rivers<sup>2</sup></b>				
Seekonk River (Element 1)	2.806	3.631	1.29	18.0
Providence River (Elements 2-4)	21.322	85.100	3.99	57.7
Fox Point Reach (Element 2)	3.000	21.095	7.03	18.3
Sabin Point Reach (Element 3)	8.535	28.926	3.39	19.3
Nyatt Point Reach (Element 4)	9.786	35.079	3.58	20.1

<sup>1</sup> See Figure 1.    <sup>2</sup> See Figure 3.

Table 5. Estimated volume of water in each element of the bay under various tide conditions. As discussed in the text, area and volume values used throughout this hypsographic analysis of the bay have been referenced to mean low water (MLW). However, as shown in Table 2, there is tidal variation around mean sea level (MSL), a water depth greater than MLW. Since it may be useful to estimate the volume of water present in each element of the bay under various conditions of the tide, we have used the tidal variation shown in Table 2 (corrected to MLW) and the area estimates from Table 4 to calculate the approximate volume of water in each element under the various tide conditions. The % change from MLW volume is given in parentheses.

Element	Neap Tide		Spring Tide		Volume (m <sup>3</sup> x10 <sup>6</sup> )	
	High	Low	High	Low	High	Low
1	130.935(18.0)	117.531(5.9)	137.531(24.0)	110.935(0)	144.127(29.9)	104.339(-5.9)
2	280.717(16.3)	254.743(5.6)	294.137(21.9)	241.323(0)	307.557(27.4)	227.903(-5.6)
3	35.191(43.1)	28.207(14.7)	38.799(57.7)	24.599(0)	42.407(72.4)	20.991(-14.7)
4	542.327(14.3)	497.131(4.8)	564.924(19.0)	474.534(0)	587.521(23.8)	451.937(-4.8)
5	174.517(9.0)	165.011(3.0)	179.359(12.0)	160.169(0)	184.201(15.0)	155.327(-3.0)
6	195.976(12.3)	181.455(4.0)	202.880(16.2)	174.551(0)	209.784(20.2)	167.647(-4.0)
7	508.576(6.1)	489.005(2.0)	518.190(8.1)	479.391(0)	527.804(10.1)	469.777(-2.0)
8	494.616(4.3)	481.184(1.4)	501.458(5.7)	474.342(0)	508.300(7.2)	467.500(-1.4)
9	228.451(13.3)	212.611(5.4)	239.363(18.7)	201.699(0)	250.275(24.1)	190.787(-5.4)
10	372.312(12.3)	345.298(4.2)	386.073(16.4)	331.537(0)	399.834(20.6)	317.776(-4.2)

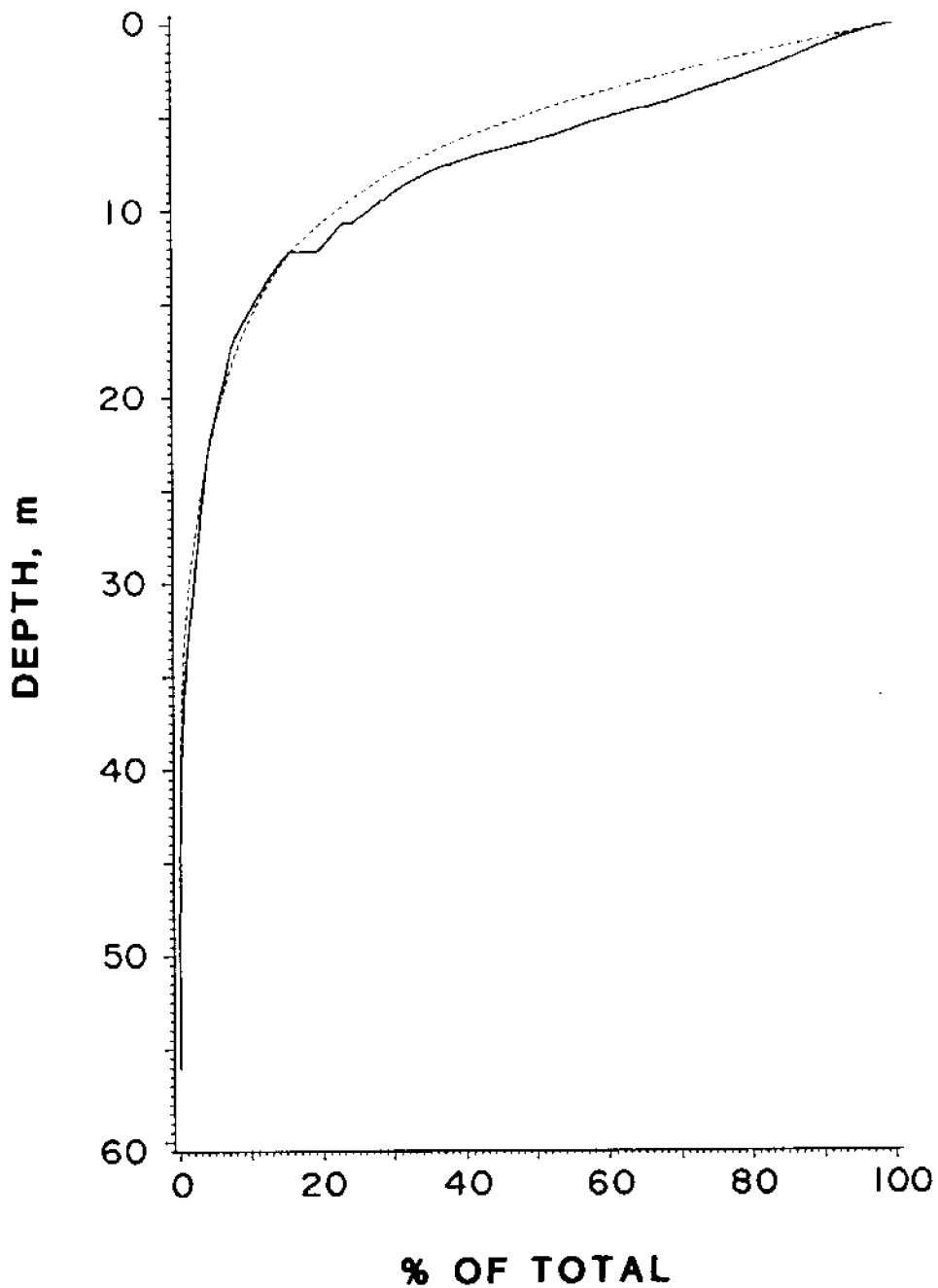


Figure 6a. Hypsographic curve for Narragansett Bay, including Mount Hope Bay and the Sakonnet River (Elements 1-10). Percentage of total area (solid line) and total volume (dashed line) below the specified depth. For example, 100% of the total area and volume lies below the depth of 0 m (the surface). The linear portion of the area curve indicates the presence of a dredged channel.

Table 6a. The area and volume of Narragansett Bay, including Mount Hope Bay and the Sakonnet River (Elements 1-10) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0-1	30.335	324.520	0	341.715	100.000	2673.080	100.000
1-2	20.839	300.608	1	311.380	91.120	2348.560	87.860
2-3	23.471	278.847	2	290.541	85.020	2047.952	76.610
3-4	27.432	253.584	3	267.070	78.160	1769.105	66.180
4-5	31.935	224.429	4	239.638	70.130	1515.521	56.700
5-6	26.348	193.418	5	207.703	60.780	1291.092	48.300
6-7	35.019	163.505	6	181.354	53.070	1097.674	41.060
7-8	26.800	132.070	7	146.335	42.820	934.169	34.950
8-9	15.600	111.472	8	119.535	34.980	802.099	30.010
9-10	12.181	97.768	9	103.935	30.420	690.627	25.840
10-11	15.716	84.030	10	91.755	26.850	592.859	22.180
11-12	7.781	72.155	11	76.039	22.250	508.829	19.040
12-13	20.413	54.026	12	68.258	19.980	436.674	16.340
13-14	6.052	44.615	13	47.845	14.000	382.648	14.310
14-15	5.277	39.102	14	41.793	12.230	338.033	12.650
15-16	5.161	33.918	15	36.516	10.690	298.931	11.180
16-17	4.335	29.131	16	31.355	9.180	265.013	9.910
17-18	2.465	25.604	17	27.019	7.910	235.882	8.820
18-19	1.935	23.583	18	24.555	7.190	210.278	7.870
19-20	2.245	21.480	19	22.619	6.620	186.695	6.980
20-21	2.129	19.168	20	20.374	5.960	165.215	6.180
21-22	2.206	17.123	21	18.245	5.340	146.047	5.460
22-23	1.690	15.122	22	16.039	4.690	128.924	4.820
23-24	1.265	13.656	23	14.348	4.200	113.802	4.260
24-25	1.045	12.505	24	13.084	3.830	100.146	3.750
25-26	1.006	11.496	25	12.039	3.520	87.641	3.280
26-27	0.865	10.598	26	11.032	3.230	76.145	2.850
27-28	0.800	9.730	27	10.168	2.980	65.547	2.450
28-29	1.110	8.785	28	9.368	2.740	55.817	2.090
29-30	0.839	7.876	29	8.258	2.420	47.032	1.760
30-31	0.800	6.978	30	7.419	2.170	39.156	1.460
31-32	1.084	6.089	31	6.619	1.940	32.178	1.200
32-33	0.877	5.053	32	5.535	1.620	26.089	0.976
33-34	0.735	4.277	33	4.658	1.360	21.036	0.787
34-35	0.723	3.553	34	3.923	1.150	16.759	0.627
35-36	0.735	2.827	35	3.200	0.936	13.206	0.494
36-37	0.529	2.171	36	2.465	0.721	10.379	0.388
37-38	0.426	1.725	37	1.935	0.566	8.208	0.307
38-39	0.374	1.303	38	1.510	0.442	6.483	0.242
39-40	0.245	1.029	39	1.135	0.332	5.180	0.194
40-41	0.116	0.831	40	0.890	0.261	4.151	0.155
41-42	0.116	0.703	41	0.774	0.227	3.320	0.124
42-43	0.129	0.602	42	0.658	0.193	2.617	0.098
43-44	0.077	0.501	43	0.529	0.155	2.015	0.075
44-45	0.103	0.424	44	0.452	0.132	1.514	0.057
45-46	0.129	0.274	45	0.348	0.102	1.090	0.041
46-47	0.013	0.208	46	0.219	0.064	0.816	0.030
47-48	0.077	0.173	47	0.206	0.060	0.608	0.023
48-49	0.039	0.117	48	0.129	0.038	0.435	0.016
49-50	0.039	0.070	49	0.090	0.026	0.318	0.012
50-51	0.013	0.050	50	0.052	0.015	0.248	0.009
51-52	0.000	0.039	51	0.039	0.011	0.198	0.007
52-53	0.000	0.039	52	0.039	0.011	0.159	0.006
53-54	0.000	0.039	53	0.039	0.011	0.120	0.004
54-55	0.000	0.039	54	0.039	0.011	0.081	0.003
55-56	0.000	0.039	55	0.039	0.011	0.042	0.002
56-57	0.039	0.003	56	0.039	0.011	0.003	0.000

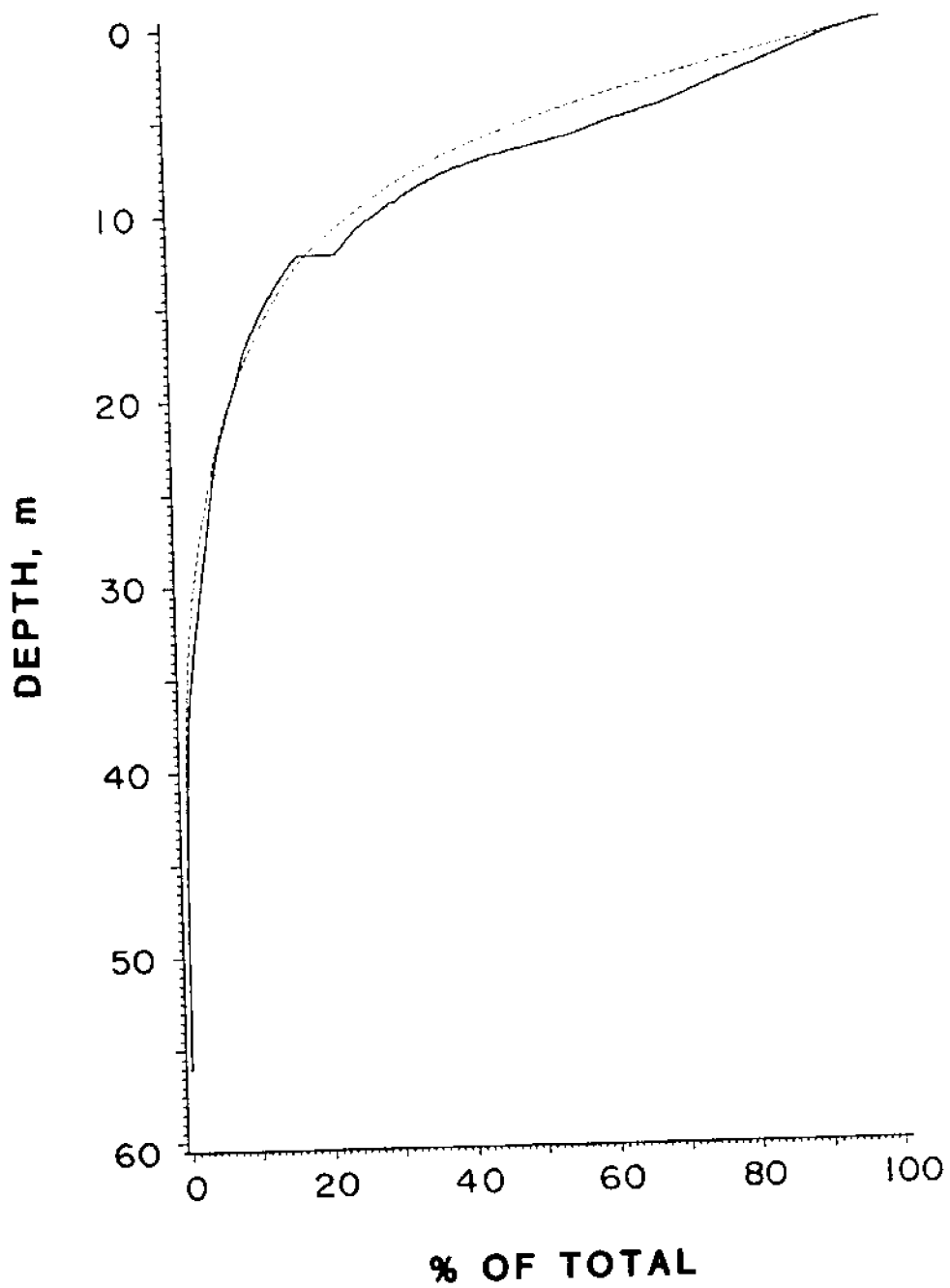


Figure 6b. Hypsographic curve for Narragansett Bay, excluding Mount Hope Bay and the Sakonnet River (Elements 1-8). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 6b. The area and volume of Narragansett Bay, excluding Mount Hope Bay and the Sakonnet River (Elements 1-8) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0- 1	23.948	241.717	0	255.548	100.000	2139.847	100.000
1- 2	15.690	223.486	1	231.600	90.630	1898.130	88.700
2- 3	16.516	207.451	2	215.909	84.490	1674.644	78.260
3- 4	16.374	191.127	3	199.393	78.030	1467.193	68.570
4- 5	18.877	174.243	4	183.019	71.620	1276.066	59.630
5- 6	19.342	153.700	5	164.142	64.230	1101.823	51.490
6- 7	27.923	130.594	6	144.800	56.660	948.123	44.310
7- 8	20.116	106.018	7	116.877	45.740	817.529	38.200
8- 9	12.413	90.425	8	96.761	37.860	711.511	33.250
9-10	10.039	79.248	9	84.348	33.010	621.086	29.020
10-11	9.161	69.212	10	74.310	29.080	541.838	25.320
11-12	5.897	62.128	11	65.148	25.490	472.626	22.090
12-13	18.516	45.949	12	59.251	23.190	410.498	19.180
13-14	4.348	38.540	13	40.735	15.940	364.549	17.040
14-15	3.923	34.324	14	36.387	14.240	326.009	15.240
15-16	3.265	30.748	15	32.464	12.700	291.685	13.630
16-17	3.084	27.560	16	29.200	11.430	260.937	12.190
17-18	2.168	24.930	17	26.116	10.220	233.377	10.910
18-19	1.819	23.024	18	23.948	9.370	208.447	9.740
19-20	2.155	21.037	19	22.129	8.660	185.423	8.670
20-21	2.052	18.807	20	19.974	7.820	164.386	7.680
21-22	2.065	16.883	21	17.923	7.010	145.579	6.800
22-23	1.600	14.980	22	15.858	6.210	128.696	6.010
23-24	1.213	13.587	23	14.258	5.580	113.716	5.310
24-25	1.006	12.488	24	13.045	5.100	100.129	4.680
25-26	1.006	11.496	25	12.039	4.710	87.641	4.100
26-27	0.865	10.598	26	11.032	4.320	76.145	3.560
27-28	0.800	9.730	27	10.168	3.980	65.547	3.060
28-29	1.110	8.785	28	9.368	3.670	55.817	2.610
29-30	0.839	7.876	29	8.258	3.230	47.032	2.200
30-31	0.800	6.978	30	7.419	2.900	39.156	1.830
31-32	1.084	6.089	31	6.619	2.590	32.178	1.500
32-33	0.877	5.053	32	5.535	2.170	26.089	1.220
33-34	0.735	4.277	33	4.658	1.820	21.036	0.983
34-35	0.723	3.553	34	3.923	1.530	16.759	0.783
35-36	0.735	2.827	35	3.200	1.250	13.206	0.617
36-37	0.529	2.171	36	2.465	0.964	10.379	0.485
37-38	0.426	1.725	37	1.935	0.757	8.208	0.383
38-39	0.374	1.303	38	1.510	0.591	6.483	0.303
39-40	0.245	1.029	39	1.135	0.444	5.180	0.242
40-41	0.116	0.831	40	0.890	0.348	4.151	0.194
41-42	0.116	0.703	41	0.774	0.303	3.320	0.155
42-43	0.129	0.602	42	0.658	0.258	2.617	0.122
43-44	0.077	0.501	43	0.529	0.207	2.015	0.094
44-45	0.103	0.424	44	0.452	0.177	1.514	0.071
45-46	0.129	0.274	45	0.348	0.136	1.090	0.051
46-47	0.013	0.208	46	0.219	0.086	0.816	0.038
47-48	0.077	0.173	47	0.206	0.081	0.608	0.028
48-49	0.039	0.117	48	0.129	0.050	0.435	0.020
49-50	0.039	0.070	49	0.090	0.035	0.318	0.015
50-51	0.013	0.050	50	0.052	0.020	0.248	0.012
51-52	0.000	0.039	51	0.039	0.015	0.198	0.009
52-53	0.000	0.039	52	0.039	0.015	0.159	0.007
53-54	0.000	0.039	53	0.039	0.015	0.120	0.006
54-55	0.000	0.039	54	0.039	0.015	0.081	0.004
55-56	0.000	0.039	55	0.039	0.015	0.042	0.002
56-57	0.039	0.003	56	0.039	0.015	0.003	0.000

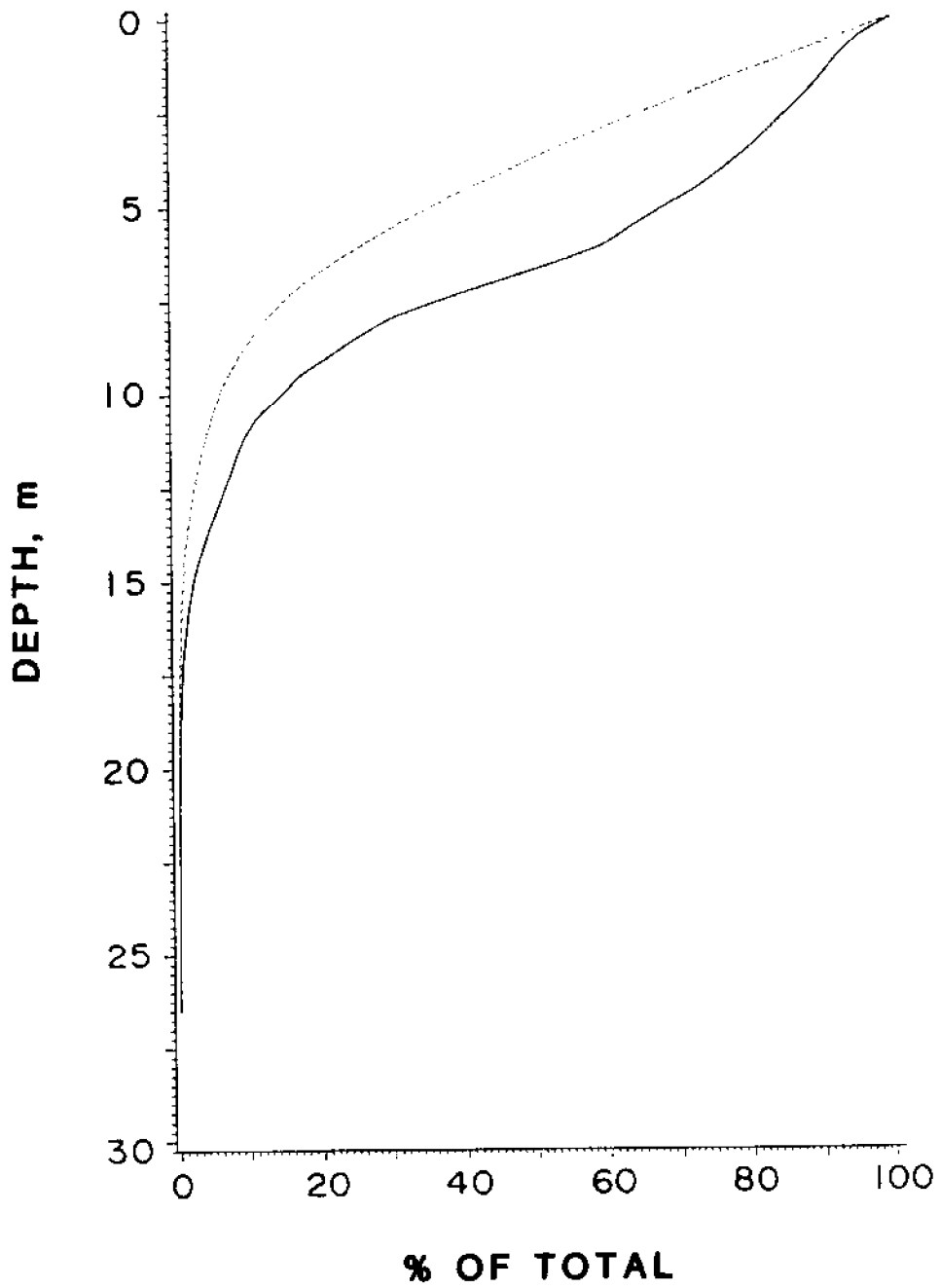


Figure 6c. Hypsographic curve for the West Passage (Elements 4-5). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 6c. The area and volume of the West Passage of Narragansett Bay (Elements 4-5, Figure 1) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0- 1	7.148	91.451	0	95.858	100.000	634.703	100.000
1- 2	4.039	86.720	1	88.709	92.540	543.252	85.590
2- 3	5.084	82.114	2	84.671	88.330	456.532	71.930
3- 4	5.677	76.917	3	79.587	83.030	374.418	58.990
4- 5	7.832	70.297	4	73.910	77.100	297.501	46.870
5- 6	7.639	62.074	5	66.077	68.930	227.204	35.800
6- 7	15.316	51.424	6	58.439	60.960	165.130	26.020
7- 8	14.645	35.208	7	43.122	44.990	113.706	17.910
8- 9	8.194	24.171	8	28.477	29.710	78.498	12.370
9-10	6.039	17.088	9	20.284	21.160	54.326	8.560
10-11	4.916	11.440	10	14.245	14.860	37.238	5.870
11-12	2.026	8.289	11	9.329	9.730	25.798	4.060
12-13	1.948	6.299	12	7.303	7.620	17.510	2.760
13-14	1.923	4.356	13	5.355	5.590	11.211	1.770
14-15	1.368	2.652	14	3.432	3.580	6.855	1.080
15-16	0.800	1.637	15	2.065	2.150	4.203	0.662
16-17	0.555	0.960	16	1.265	1.320	2.566	0.404
17-18	0.245	0.576	17	0.710	0.740	1.606	0.253
18-19	0.181	0.397	18	0.465	0.485	1.030	0.162
19-20	0.077	0.231	19	0.284	0.296	0.633	0.100
20-21	0.103	0.148	20	0.206	0.215	0.402	0.063
21-22	0.039	0.074	21	0.103	0.108	0.254	0.040
22-23	0.013	0.053	22	0.065	0.067	0.181	0.028
23-24	0.026	0.031	23	0.052	0.054	0.128	0.020
24-25	0.026	0.020	24	0.026	0.027	0.097	0.015
25-26	0.000	0.026	25	0.026	0.026	0.046	0.007
26-27	0.026	0.020	26	0.026	0.026	0.020	0.003



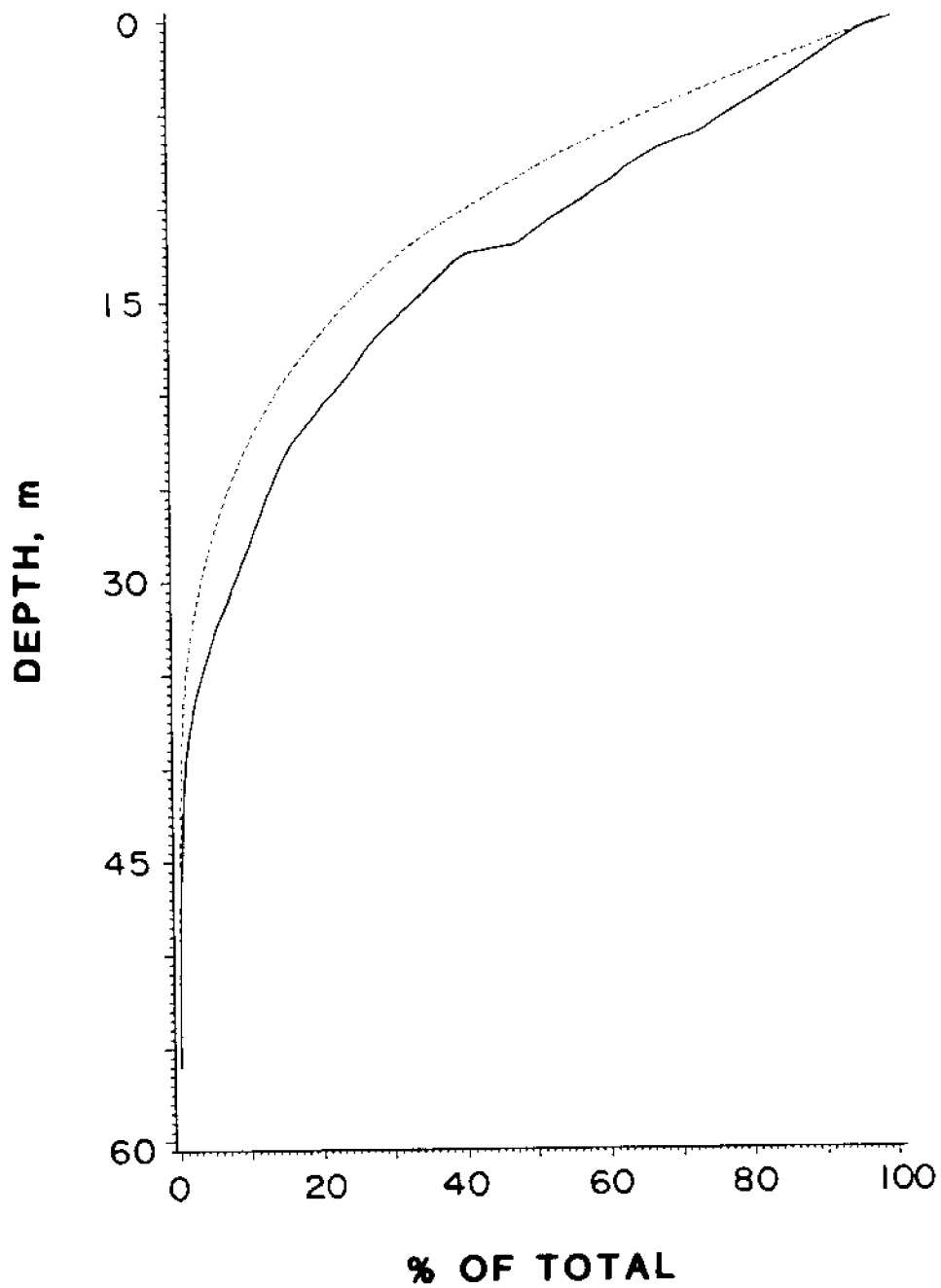


Figure 6d. Hypsographic curve for the East Passage (Elements 6-8). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 6d. The area and volume of the East Passage of Narragansett Bay (Elements 6-8, Figure 1) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0-	5.458	80.099	0	83.484	100.000	1128.288	100.000
1-	3.303	76.280	1	78.026	93.460	1048.189	92.900
2-3	3.355	72.944	2	74.722	89.510	971.909	86.140
3-4	3.303	69.695	3	71.368	85.490	898.965	79.680
4-5	3.535	66.279	4	68.064	81.530	829.270	73.500
5-6	2.890	62.912	5	64.529	77.300	762.991	67.620
6-7	3.781	59.814	6	61.639	73.830	700.079	62.050
7-8	3.019	56.307	7	57.858	69.300	640.265	56.750
8-9	2.890	53.509	8	54.839	65.690	583.958	51.760
9-10	3.213	50.429	9	51.948	62.230	530.449	47.010
10-11	3.574	46.832	10	48.735	58.380	480.020	42.540
11-12	3.316	43.517	11	45.161	54.100	433.188	38.390
12-13	6.929	37.276	12	41.845	50.120	389.671	34.540
13-14	2.245	33.831	13	34.916	41.820	352.395	31.230
14-15	2.439	31.449	14	32.671	39.130	318.564	28.230
15-16	2.400	28.985	15	30.232	36.210	287.115	25.450
16-17	2.516	26.500	16	27.832	33.340	258.130	22.880
17-18	1.884	24.275	17	25.316	30.320	231.630	20.530
18-19	1.600	22.597	18	23.432	28.070	207.355	18.380
19-20	2.077	20.794	19	21.832	26.150	184.758	16.370
20-21	1.948	18.646	20	19.755	23.660	163.964	14.530
21-22	2.013	16.803	21	17.806	21.330	145.318	12.880
22-23	1.587	14.927	22	15.794	18.920	128.515	11.390
23-24	1.213	13.535	23	14.206	17.020	113.588	10.070
24-25	0.981	12.457	24	12.994	15.560	100.053	8.870
25-26	1.006	11.470	25	12.013	14.390	87.596	7.760
26-27	0.839	10.579	26	11.006	13.180	76.126	6.750
27-28	0.800	9.730	27	10.168	12.180	65.547	5.810
28-29	1.110	8.785	28	9.368	11.220	55.817	4.950
29-30	0.839	7.876	29	8.258	9.890	47.032	4.170
30-31	0.800	6.978	30	7.419	8.890	39.156	3.470
31-32	1.084	6.089	31	6.619	7.930	32.178	2.850
32-33	0.877	5.053	32	5.535	6.630	26.089	2.310
33-34	0.735	4.277	33	4.658	5.580	21.036	1.860
34-35	0.723	3.553	34	3.923	4.700	16.759	1.490
35-36	0.735	2.827	35	3.200	3.830	13.206	1.170
36-37	0.529	2.171	36	2.465	2.950	10.379	0.920
37-38	0.426	1.725	37	1.935	2.320	8.208	0.727
38-39	0.374	1.303	38	1.510	1.810	6.483	0.574
39-40	0.245	1.029	39	1.135	1.360	5.180	0.459
40-41	0.116	0.831	40	0.890	1.070	4.151	0.368
41-42	0.116	0.703	41	0.774	0.927	3.320	0.294
42-43	0.129	0.602	42	0.658	0.788	2.617	0.232
43-44	0.077	0.501	43	0.529	0.634	2.015	0.178
44-45	0.103	0.424	44	0.452	0.541	1.514	0.134
45-46	0.129	0.274	45	0.348	0.417	1.090	0.096
46-47	0.013	0.208	46	0.219	0.263	0.816	0.072
47-48	0.077	0.173	47	0.206	0.247	0.608	0.054
48-49	0.039	0.117	48	0.129	0.155	0.435	0.038
49-50	0.039	0.070	49	0.090	0.108	0.318	0.028
50-51	0.013	0.050	50	0.052	0.062	0.248	0.022
51-52	0.000	0.039	51	0.039	0.046	0.198	0.017
52-53	0.000	0.039	52	0.039	0.046	0.159	0.014
53-54	0.000	0.039	53	0.039	0.046	0.120	0.011
54-55	0.000	0.039	54	0.039	0.046	0.081	0.007
55-56	0.000	0.039	55	0.039	0.046	0.042	0.004
56-57	0.039	0.003	56	0.039	0.046	0.003	0.000

Table 7a. The area and volume of the Providence River (Element 1, coarse grid analysis; Figure 1) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0- 1	4.800	18.718	0	21.277	100.000	110.935	100.000
1- 2	3.471	14.684	1	16.477	77.440	92.217	83.130
2- 3	2.090	11.890	2	13.006	61.130	77.532	69.890
3- 4	1.458	10.218	3	10.916	51.300	65.642	59.170
4- 5	0.994	8.972	4	9.458	44.450	55.424	49.960
5- 6	0.852	8.043	5	8.464	39.780	46.452	41.870
6- 7	0.955	7.001	6	7.613	35.780	38.409	34.620
7- 8	0.323	6.463	7	6.658	31.290	31.409	28.310
8- 9	0.194	6.250	8	6.335	29.780	24.945	22.490
9-10	0.219	6.065	9	6.142	28.870	18.696	16.850
10-11	0.142	5.834	10	5.923	27.840	12.630	11.390
11-12	0.116	5.731	11	5.781	27.170	6.797	6.130
12-13	5.665	1.065	12	5.665	26.620	1.065	0.960
13-14	0.000	0.000	13	0.000	0.000	0.000	0.000

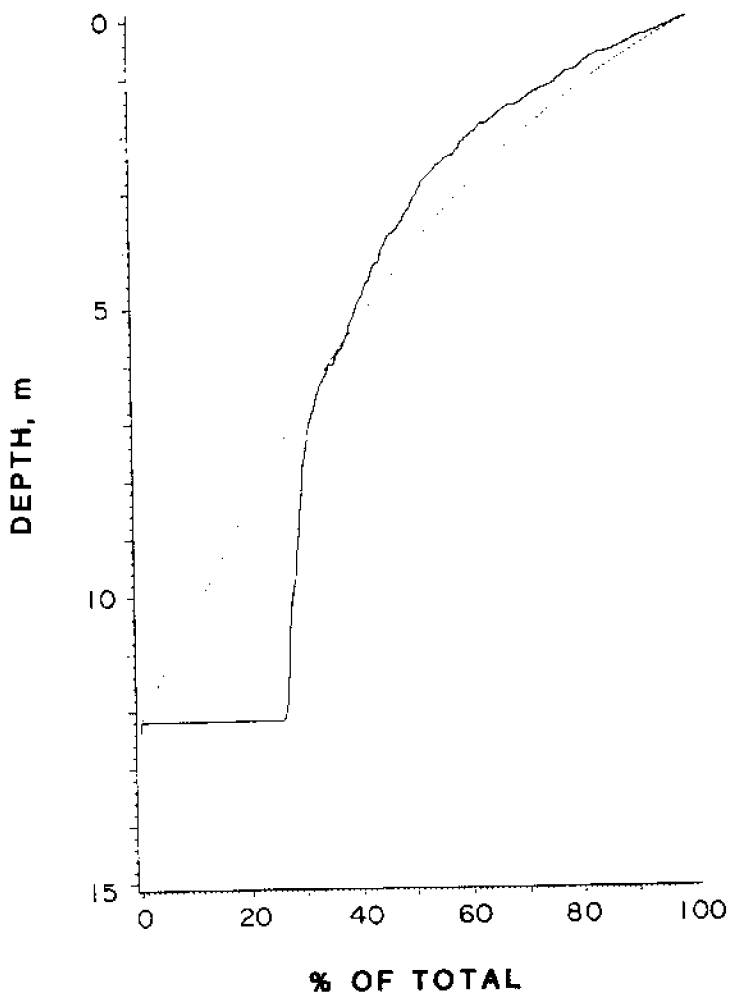


Figure 7a. Hypsographic curve for the Providence River (Element 1). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 7b. The area and volume of Upper Narragansett Bay (Element 2, Figure 1) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0- 1	3.226	41.510	0	43.290	100.000	241.323	100.000
1- 2	2.465	38.699	1	40.064	92.550	199.813	82.800
2- 3	3.239	36.098	2	37.600	86.860	161.113	66.760
3- 4	3.703	32.518	3	34.361	79.370	125.015	51.800
4- 5	6.052	28.063	4	30.658	70.820	92.497	38.330
5- 6	7.768	20.316	5	24.606	56.840	64.434	26.700
6- 7	7.755	12.144	6	16.839	38.900	44.118	18.280
7- 8	2.039	7.949	7	9.084	20.980	31.974	13.250
8- 9	1.110	6.447	8	7.045	16.270	24.026	9.960
9-10	0.555	5.639	9	5.935	13.710	17.579	7.280
10-11	0.503	5.097	10	5.381	12.430	11.940	4.950
11-12	0.439	4.591	11	4.877	11.270	6.843	2.840
12-13	3.974	1.309	12	4.439	10.250	2.252	0.933
13-14	0.181	0.353	13	0.465	1.070	0.943	0.391
14-15	0.116	0.223	14	0.284	0.656	0.590	0.244
15-16	0.065	0.126	15	0.168	0.387	0.367	0.152
16-17	0.013	0.099	16	0.103	0.238	0.241	0.100
17-18	0.039	0.079	17	0.090	0.209	0.142	0.059
18-19	0.039	0.031	18	0.052	0.119	0.063	0.026
19-20	0.000	0.013	19	0.013	0.030	0.032	0.013
20-21	0.000	0.013	20	0.013	0.030	0.019	0.008
21-22	0.013	0.006	21	0.013	0.030	0.006	0.003

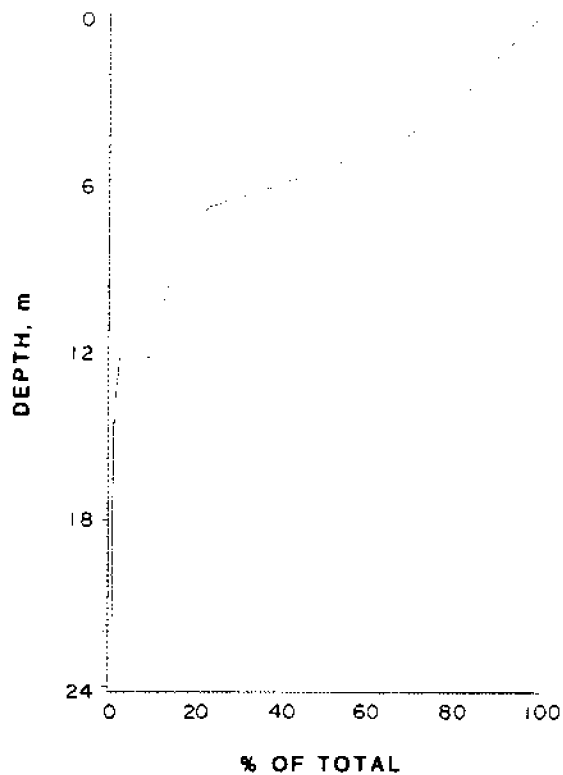


Figure 7b. Hypsographic curve for the Upper Bay (Element 2). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 7c. The area and volume of Greenwich Bay (Element 3, Figure 1) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0-1	3.316	9.939	0	11.639	100.000	24.599	100.000
1-2	2.413	7.102	1	8.323	71.510	14.660	59.600
2-3	2.748	4.405	2	5.910	50.780	7.558	30.720
3-4	2.232	1.778	3	3.161	27.160	3.153	12.820
4-5	0.465	0.632	4	0.929	7.980	1.375	5.590
5-6	0.194	0.356	5	0.465	3.990	0.743	3.020
6-7	0.116	0.212	6	0.271	2.330	0.387	1.570
7-8	0.090	0.091	7	0.155	1.330	0.175	0.711
8-9	0.026	0.049	8	0.065	0.554	0.084	0.342
9-10	0.013	0.026	9	0.039	0.333	0.035	0.144
10-11	0.026	0.009	10	0.026	0.222	0.009	0.038

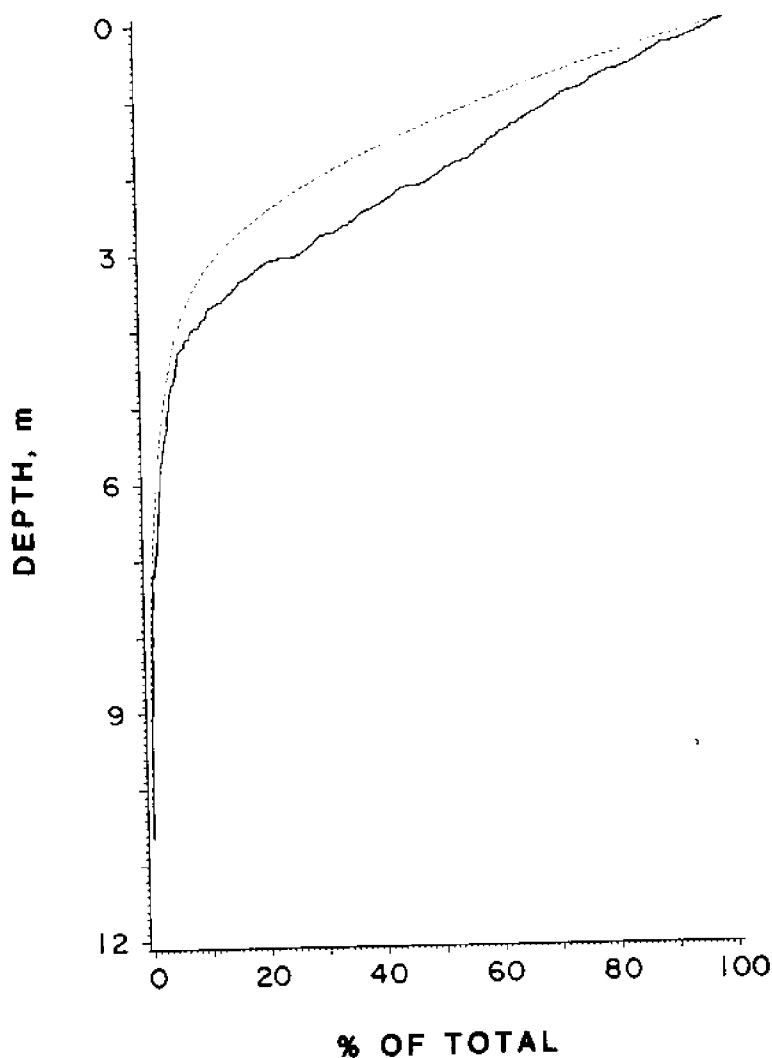


Figure 7c. Hypsographic curve for Greenwich Bay (Element 3). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 7d. The area and volume of the Upper West Passage of Narragansett Bay (Element 4, Figure 1) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0- 1	5.794	74.418	0	77.922	100.000	474.534	100.000
1- 2	3.406	70.426	1	72.129	92.560	400.116	84.320
2- 3	4.297	66.556	2	68.722	88.190	329.691	69.480
3- 4	5.006	62.052	3	64.426	82.680	263.135	55.450
4- 5	6.748	56.264	4	59.419	76.250	201.083	42.370
5- 6	6.723	49.194	5	52.671	67.590	144.819	30.520
6- 7	14.323	39.518	6	45.948	58.970	95.625	20.150
7- 8	13.716	24.208	7	31.626	40.590	56.107	11.820
8- 9	6.994	14.239	8	17.910	22.980	31.899	6.720
9-10	4.968	8.226	9	10.916	14.010	17.660	3.720
10-11	3.290	4.015	10	5.948	7.630	9.435	1.990
11-12	1.032	2.085	11	2.658	3.410	5.419	1.140
12-13	0.684	1.239	12	1.626	2.090	3.334	0.703
13-14	0.335	0.739	13	0.942	1.210	2.096	0.442
14-15	0.245	0.483	14	0.606	0.778	1.357	0.286
15-16	0.077	0.322	15	0.361	0.464	0.873	0.184
16-17	0.155	0.199	16	0.284	0.364	0.551	0.116
17-18	0.013	0.119	17	0.129	0.166	0.353	0.074
18-19	0.013	0.111	18	0.116	0.149	0.233	0.049
19-20	0.039	0.074	19	0.103	0.132	0.122	0.026
20-21	0.039	0.039	20	0.065	0.083	0.048	0.010
21-22	0.026	0.009	21	0.026	0.033	0.009	0.002

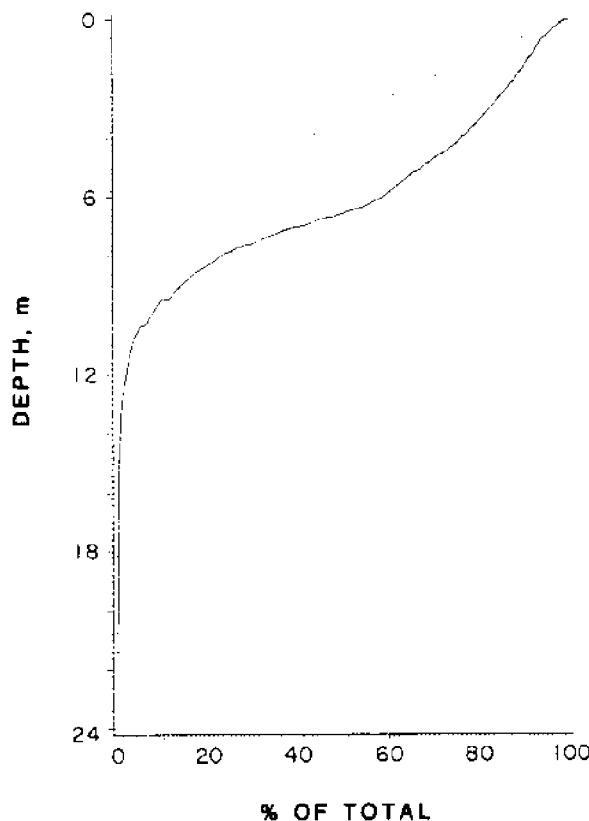


Figure 7d. Hypsographic curve for the Upper West Passage (Element 4). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

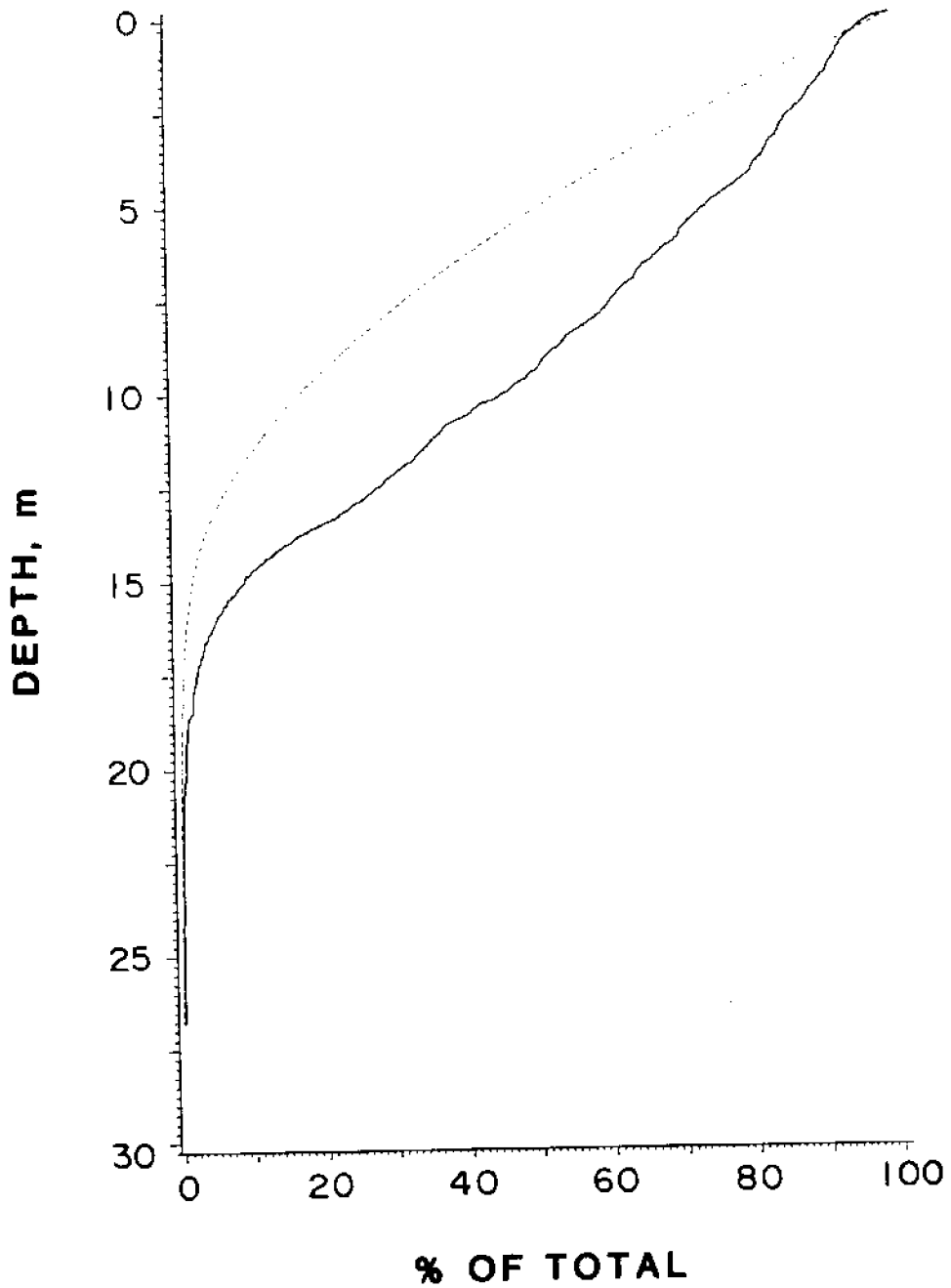


Figure 8a. Hypsographic curve for the Lower West Passage (Element 5). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 8a. The area and volume of the Lower West Passage of Narragansett Bay (Element 5, Figure 1) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0- 1	1.355	17.033	0	17.935	100.000	160.169	100.000
1- 2	0.632	16.295	1	16.581	92.450	143.136	89.370
2- 3	0.787	15.559	2	15.948	88.920	126.841	79.190
3- 4	0.671	14.865	3	15.161	84.530	111.282	69.480
4- 5	1.084	14.033	4	14.490	80.790	96.418	60.200
5- 6	0.916	12.880	5	13.406	74.750	82.385	51.440
6- 7	0.994	11.906	6	12.490	69.640	69.505	43.390
7- 8	0.929	11.000	7	11.497	64.100	57.599	35.960
8- 9	1.200	9.933	8	10.568	58.920	46.599	29.090
9-10	1.071	8.863	9	9.368	52.230	36.666	22.890
10-11	1.626	7.424	10	8.297	46.260	27.803	17.360
11-12	0.994	6.204	11	6.671	37.190	20.379	12.720
12-13	1.265	5.060	12	5.677	31.650	14.175	8.850
13-14	1.587	3.616	13	4.413	24.600	9.115	5.690
14-15	1.123	2.169	14	2.826	15.760	5.499	3.430
15-16	0.723	1.315	15	1.703	9.500	3.330	2.080
16-17	0.400	0.761	16	0.981	5.470	2.015	1.260
17-18	0.232	0.457	17	0.581	3.240	1.254	0.783
18-19	0.168	0.285	18	0.348	1.940	0.797	0.497
19-20	0.039	0.157	19	0.181	1.010	0.511	0.319
20-21	0.065	0.109	20	0.142	0.791	0.354	0.221
21-22	0.013	0.065	21	0.077	0.432	0.246	0.153
22-23	0.013	0.053	22	0.065	0.360	0.181	0.113
23-24	0.000	0.052	23	0.052	0.288	0.128	0.080
24-25	0.026	0.031	24	0.052	0.288	0.076	0.048
25-26	0.000	0.026	25	0.026	0.144	0.045	0.028
26-27	0.026	0.020	26	0.026	0.144	0.020	0.012



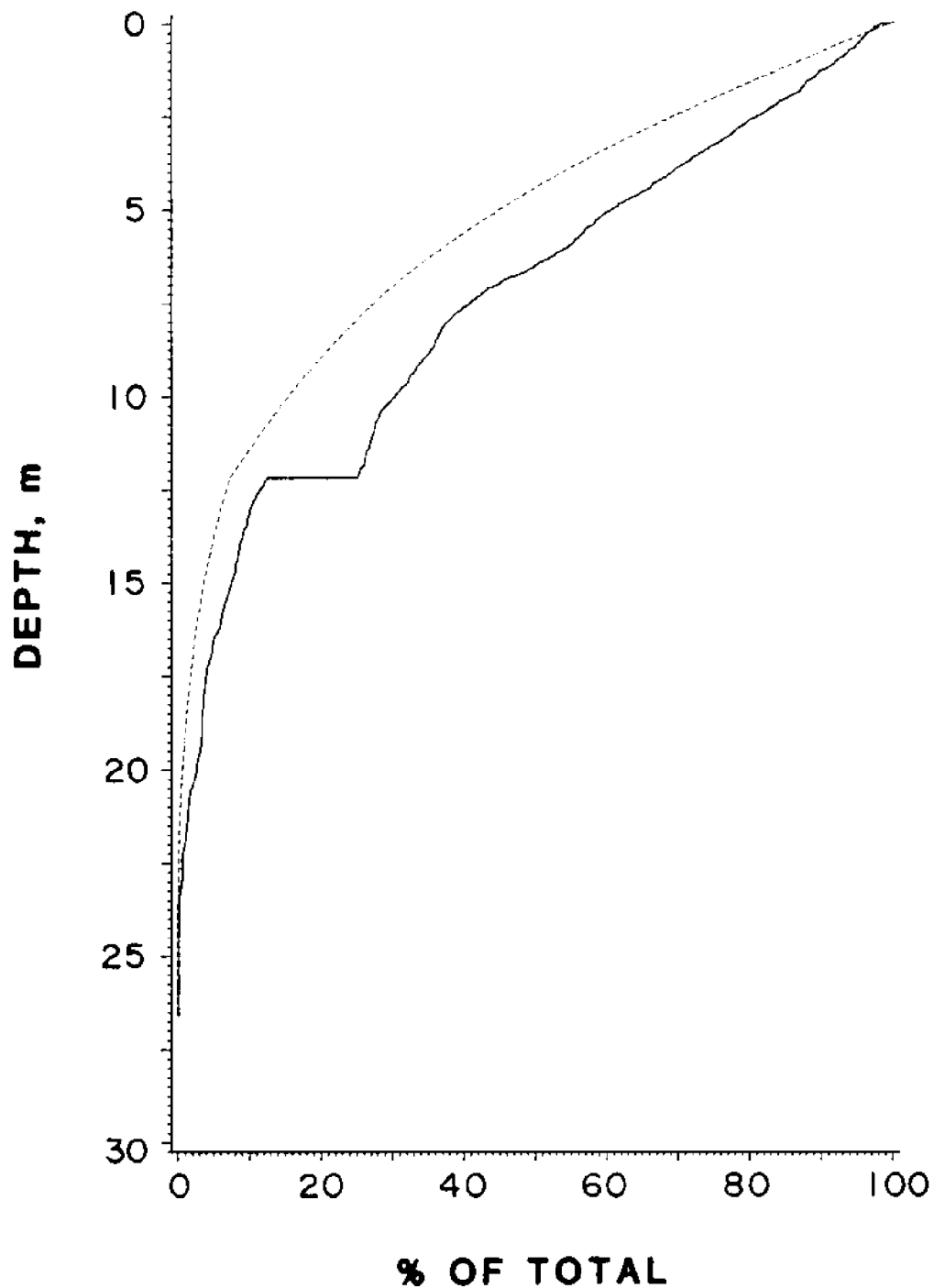


Figure 8b. Hypsographic curve for the Upper East Passage (Element 6). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 8b. The area and volume of the Upper East Passage of Narragansett Bay (Element 6, Figure 1) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0- 1	1.858	22.714	0	23.806	100.000	174.551	100.000
1- 2	1.639	21.121	1	21.948	92.200	151.837	86.990
2- 3	1.948	19.270	2	20.310	85.310	130.716	74.890
3- 4	1.910	17.378	3	18.361	77.130	111.446	63.850
4- 5	1.961	15.482	4	16.452	69.110	94.068	53.890
5- 6	1.471	13.677	5	14.490	60.870	78.586	45.020
6- 7	2.335	11.891	6	13.019	54.690	64.909	37.190
7- 8	1.716	9.746	7	10.684	44.880	53.018	30.370
8- 9	0.800	8.590	8	8.968	37.670	43.272	24.790
9-10	0.929	7.714	9	8.168	34.310	34.683	19.870
10-11	0.735	6.771	10	7.239	30.410	26.968	15.450
11-12	0.465	6.299	11	6.503	27.320	20.198	11.570
12-13	3.613	3.314	12	6.039	25.370	13.899	7.960
13-14	0.374	2.252	13	2.426	10.190	10.585	6.060
14-15	0.258	1.942	14	2.052	8.620	8.333	4.770
15-16	0.361	1.602	15	1.794	7.530	6.391	3.660
16-17	0.335	1.248	16	1.432	6.020	4.789	2.740
17-18	0.232	0.950	17	1.097	4.610	3.541	2.030
18-19	0.077	0.823	18	0.865	3.630	2.591	1.480
19-20	0.155	0.719	19	0.787	3.310	1.768	1.010
20-21	0.271	0.476	20	0.632	2.660	1.049	0.601
21-22	0.129	0.302	21	0.361	1.520	0.573	0.328
22-23	0.103	0.151	22	0.232	0.976	0.271	0.155
23-24	0.090	0.064	23	0.129	0.542	0.120	0.069
24-25	0.013	0.029	24	0.039	0.163	0.057	0.032
25-26	0.013	0.020	25	0.026	0.108	0.028	0.016
26-27	0.013	0.008	26	0.013	0.054	0.008	0.005

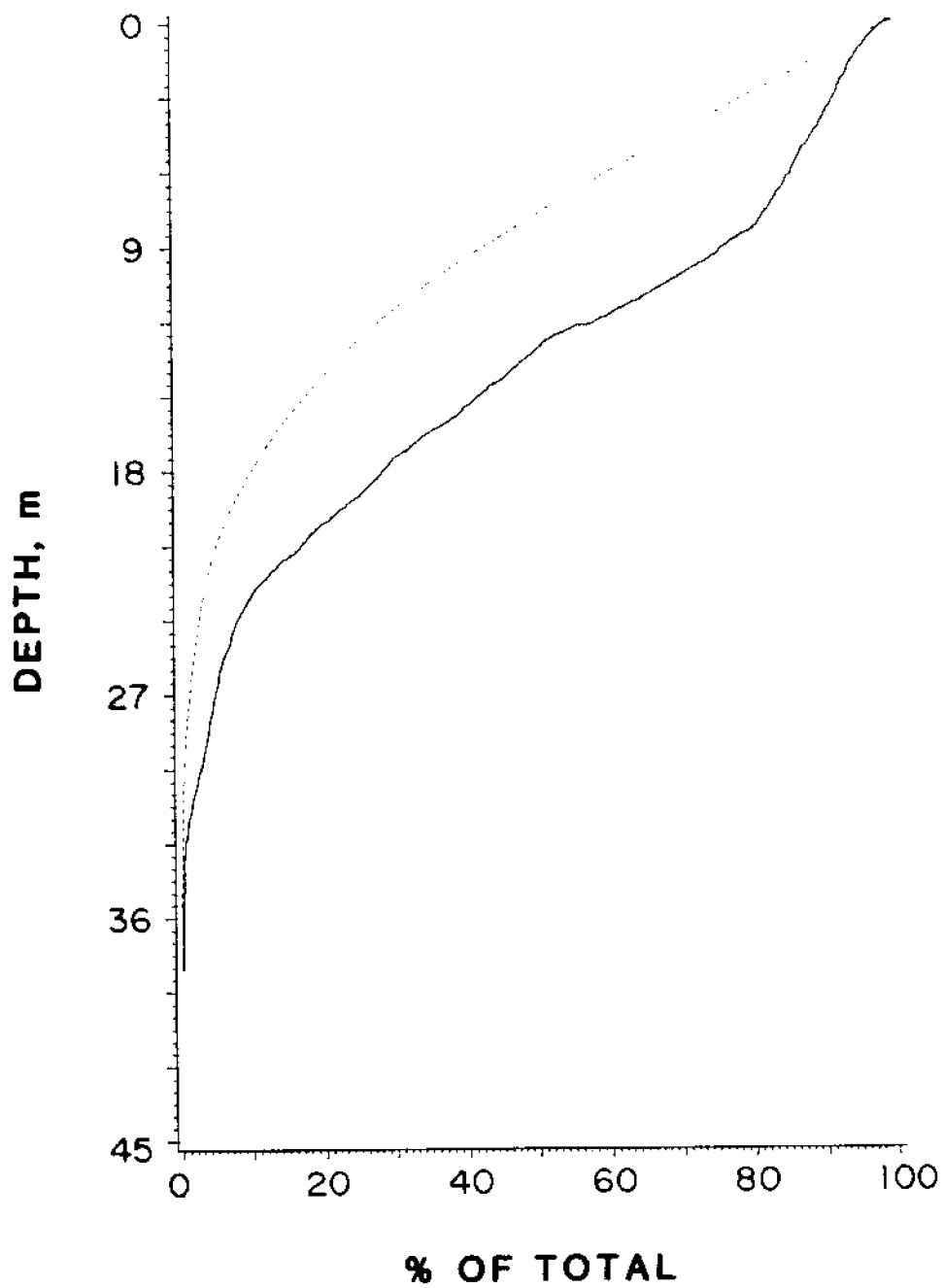


Figure 8c. Hypsographic curve for the Middle East Passage (Element 7). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 8c. The area and volume of the Middle East Passage of Narragansett Bay (Element 7, Figure 1) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0- 1	1.419	33.453	0	34.335	100.000	479.391	100.000
1- 2	0.800	32.457	1	32.916	95.870	445.938	93.020
2- 3	0.594	31.802	2	32.116	93.540	413.480	86.250
3- 4	0.645	31.196	3	31.523	91.810	381.678	79.620
4- 5	0.723	30.503	4	30.877	89.930	350.482	73.110
5- 6	0.697	29.743	5	30.155	87.820	319.979	66.750
6- 7	0.735	29.098	6	29.458	85.790	290.236	60.540
7- 8	0.826	28.330	7	28.723	83.650	261.138	54.470
8- 9	1.548	27.223	8	27.897	81.250	232.808	48.560
9-10	1.768	25.522	9	26.348	76.740	205.585	42.880
10-11	2.129	23.487	10	24.581	71.590	180.063	37.560
11-12	2.348	21.286	11	22.452	65.390	156.576	32.660
12-13	2.697	18.535	12	20.103	58.550	135.291	28.220
13-14	1.458	16.703	13	17.406	50.700	116.756	24.360
14-15	1.497	15.188	14	15.948	46.450	100.052	20.870
15-16	1.406	13.730	15	14.452	42.090	84.865	17.700
16-17	1.819	12.057	16	13.045	37.990	71.135	14.840
17-18	1.329	10.470	17	11.226	32.690	59.078	12.320
18-19	1.226	9.275	18	9.897	28.820	48.608	10.140
19-20	1.497	7.890	19	8.671	25.250	39.333	8.200
20-21	1.303	6.441	20	7.174	20.890	31.443	6.560
21-22	1.329	5.234	21	5.871	17.100	25.002	5.220
22-23	1.071	3.972	22	4.542	13.230	19.768	4.120
23-24	0.671	3.135	23	3.471	10.110	15.795	3.290
24-25	0.374	2.577	24	2.800	8.150	12.660	2.640
25-26	0.452	2.149	25	2.426	7.070	10.083	2.100
26-27	0.258	1.831	26	1.974	5.750	7.935	1.660
27-28	0.284	1.568	27	1.716	5.000	6.103	1.270
28-29	0.206	1.340	28	1.432	4.170	4.535	0.946
29-30	0.271	1.108	29	1.226	3.570	3.195	0.666
30-31	0.297	0.800	30	0.955	2.780	2.087	0.435
31-32	0.284	0.510	31	0.658	1.920	1.287	0.268
32-33	0.181	0.299	32	0.374	1.090	0.777	0.162
33-34	0.065	0.162	33	0.194	0.564	0.478	0.100
34-35	0.013	0.127	34	0.129	0.376	0.316	0.066
35-36	0.052	0.089	35	0.116	0.338	0.189	0.039
36-37	0.013	0.060	36	0.065	0.188	0.101	0.021
37-38	0.026	0.039	37	0.052	0.150	0.041	0.009
38-39	0.026	0.002	38	0.026	0.075	0.002	0.000

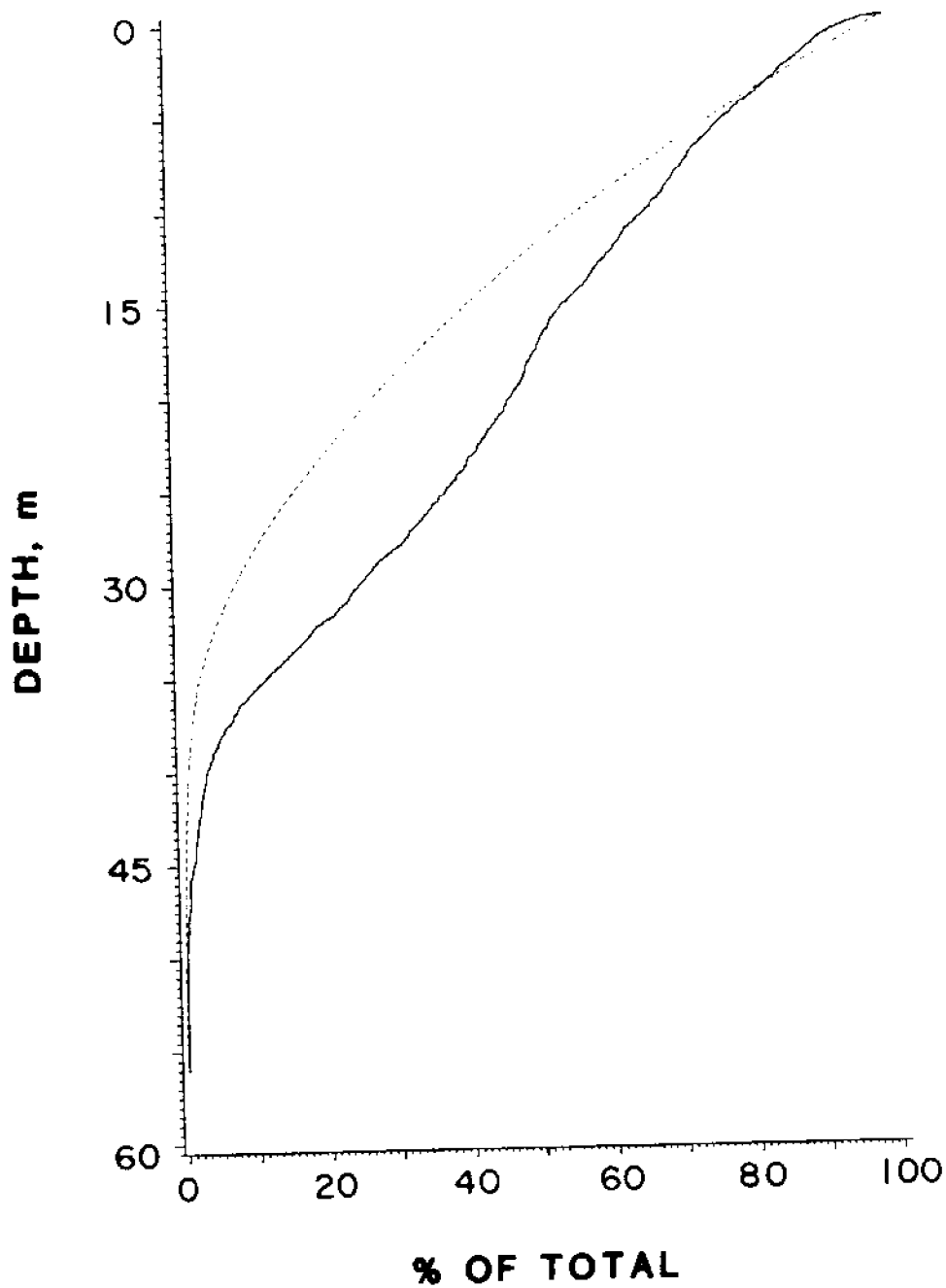


Figure 8d. Hypsographic curve for the Lower East Passage (Element 8). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 8d. The area and volume of the Lower East Passage of Narragansett Bay (Element 8, Figure 1) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0- 1	2.181	23.931	0	25.342	100.000	474.342	100.000
1- 2	0.865	22.702	1	23.161	91.400	450.411	94.950
2- 3	0.813	21.872	2	22.297	87.980	427.709	90.170
3- 4	0.748	21.121	3	21.484	84.780	405.837	85.560
4- 5	0.852	20.294	4	20.735	81.820	384.716	81.110
5- 6	0.723	19.491	5	19.884	78.460	364.422	76.830
6- 7	0.710	18.825	6	19.161	75.610	344.930	72.720
7- 8	0.477	18.231	7	18.452	72.810	326.106	68.750
8- 9	0.542	17.696	8	17.974	70.930	307.875	64.910
9-10	0.516	17.193	9	17.432	68.790	290.178	61.170
10-11	0.710	16.575	10	16.916	66.750	272.986	57.550
11-12	0.503	15.933	11	16.206	63.950	256.411	54.060
12-13	0.619	15.427	12	15.703	61.970	240.478	50.700
13-14	0.413	14.876	13	15.084	59.520	225.052	47.440
14-15	0.684	14.318	14	14.671	57.890	210.176	44.310
15-16	0.632	13.653	15	13.987	55.190	195.857	41.290
16-17	0.361	13.196	16	13.355	52.700	182.205	38.410
17-18	0.323	12.855	17	12.994	51.270	169.009	35.630
18-19	0.297	12.499	18	12.671	50.000	156.154	32.920
19-20	0.426	12.185	19	12.374	48.830	143.655	30.290
20-21	0.374	11.729	20	11.948	47.150	131.470	27.720
21-22	0.555	11.267	21	11.574	45.670	119.742	25.240
22-23	0.413	10.804	22	11.019	43.480	108.475	22.870
23-24	0.452	10.336	23	10.606	41.850	97.671	20.590
24-25	0.594	9.852	24	10.155	40.070	87.335	18.410
25-26	0.542	9.302	25	9.561	37.730	77.483	16.330
26-27	0.568	8.739	26	9.019	35.590	68.181	14.370
27-28	0.516	8.162	27	8.452	33.350	59.442	12.530
28-29	0.903	7.445	28	7.935	31.310	51.280	10.810
29-30	0.568	6.768	29	7.032	27.750	43.835	9.240
30-31	0.503	6.178	30	6.465	25.510	37.067	7.810
31-32	0.800	5.579	31	5.961	23.520	30.889	6.510
32-33	0.697	4.754	32	5.161	20.370	25.310	5.340
33-34	0.671	4.115	33	4.465	17.620	20.556	4.330
34-35	0.710	3.426	34	3.794	14.970	16.441	3.470
35-36	0.684	2.739	35	3.084	12.170	13.015	2.740
36-37	0.516	2.111	36	2.400	9.470	10.276	2.170
37-38	0.400	1.687	37	1.884	7.430	8.165	1.720
38-39	0.348	1.301	38	1.484	5.860	6.478	1.370
39-40	0.245	1.029	39	1.135	4.480	5.177	1.090
40-41	0.116	0.831	40	0.890	3.510	4.148	0.874
41-42	0.116	0.703	41	0.774	3.050	3.317	0.699
42-43	0.129	0.602	42	0.658	2.600	2.614	0.551
43-44	0.077	0.501	43	0.529	2.090	2.012	0.424
44-45	0.103	0.424	44	0.452	1.780	1.511	0.319
45-46	0.129	0.274	45	0.348	1.370	1.087	0.229
46-47	0.013	0.208	46	0.219	0.866	0.813	0.171
47-48	0.077	0.173	47	0.206	0.815	0.606	0.128
48-49	0.039	0.117	48	0.129	0.509	0.433	0.091
49-50	0.039	0.070	49	0.090	0.356	0.317	0.067
50-51	0.013	0.050	50	0.052	0.204	0.247	0.052
51-52	0.000	0.039	51	0.039	0.153	0.197	0.041
52-53	0.000	0.039	52	0.039	0.153	0.158	0.033
53-54	0.000	0.039	53	0.039	0.153	0.119	0.025
54-55	0.000	0.039	54	0.039	0.153	0.081	0.017
55-56	0.000	0.039	55	0.039	0.153	0.042	0.009
56-57	0.039	0.003	56	0.039	0.153	0.003	0.001

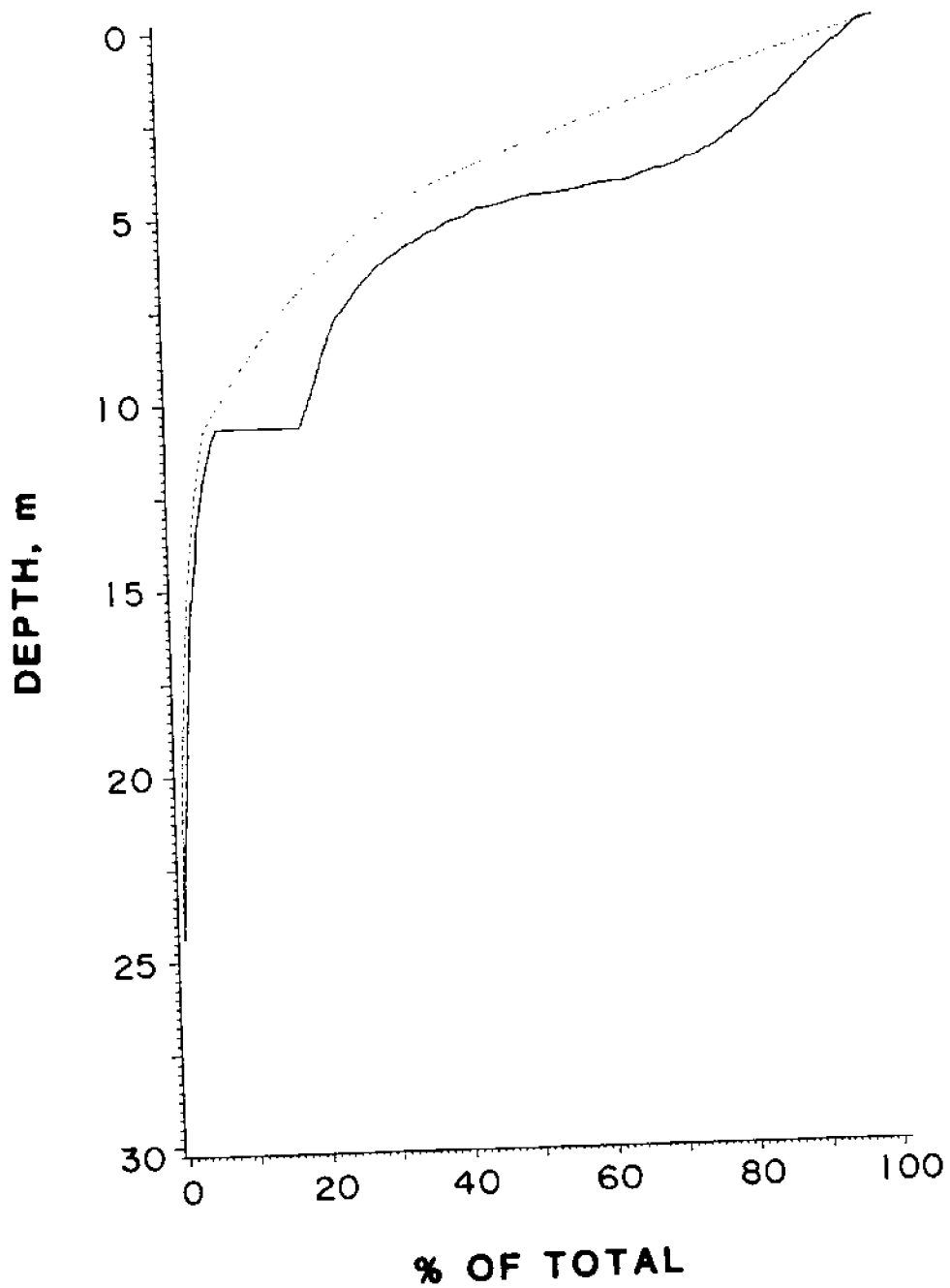


Figure 9a. Hypsographic curve for Mount Hope Bay (Element 9). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 2a. The area and volume of Mount Hope Bay (Element 9, Figure 1) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0-1	2.826	33.558	0	35.200	100.000	201.699	100.000
1-2	1.897	31.386	1	32.374	91.970	168.141	83.360
2-3	2.284	29.348	2	30.477	86.580	136.755	67.800
3-4	4.142	26.529	3	28.193	80.100	107.408	53.250
4-5	8.955	19.603	4	24.052	68.330	80.878	40.100
5-6	3.497	13.201	5	15.097	42.890	61.275	30.380
6-7	2.219	10.338	6	11.600	32.950	48.074	23.830
7-8	1.277	8.714	7	9.381	26.650	37.736	18.710
8-9	0.606	7.766	8	8.103	23.020	29.022	14.390
9-10	0.606	7.187	9	7.497	21.300	21.256	10.540
10-11	4.865	5.177	10	6.890	19.570	14.069	6.980
11-12	0.439	1.805	11	2.026	5.760	8.892	4.410
12-13	0.310	1.431	12	1.587	4.510	7.087	3.510
13-14	0.206	1.152	13	1.277	3.630	5.657	2.800
14-15	0.181	0.978	14	1.071	3.040	4.504	2.230
15-16	0.219	0.777	15	0.890	2.530	3.527	1.750
16-17	0.065	0.649	16	0.671	1.910	2.750	1.360
17-18	0.090	0.563	17	0.606	1.720	2.101	1.040
18-19	0.103	0.471	18	0.516	1.470	1.538	0.763
19-20	0.065	0.388	19	0.413	1.170	1.067	0.529
20-21	0.077	0.309	20	0.348	0.990	0.679	0.336
21-22	0.116	0.204	21	0.271	0.770	0.370	0.183
22-23	0.090	0.117	22	0.155	0.440	0.165	0.082
23-24	0.052	0.043	23	0.065	0.183	0.049	0.024
24-25	0.013	0.005	24	0.013	0.037	0.005	0.003



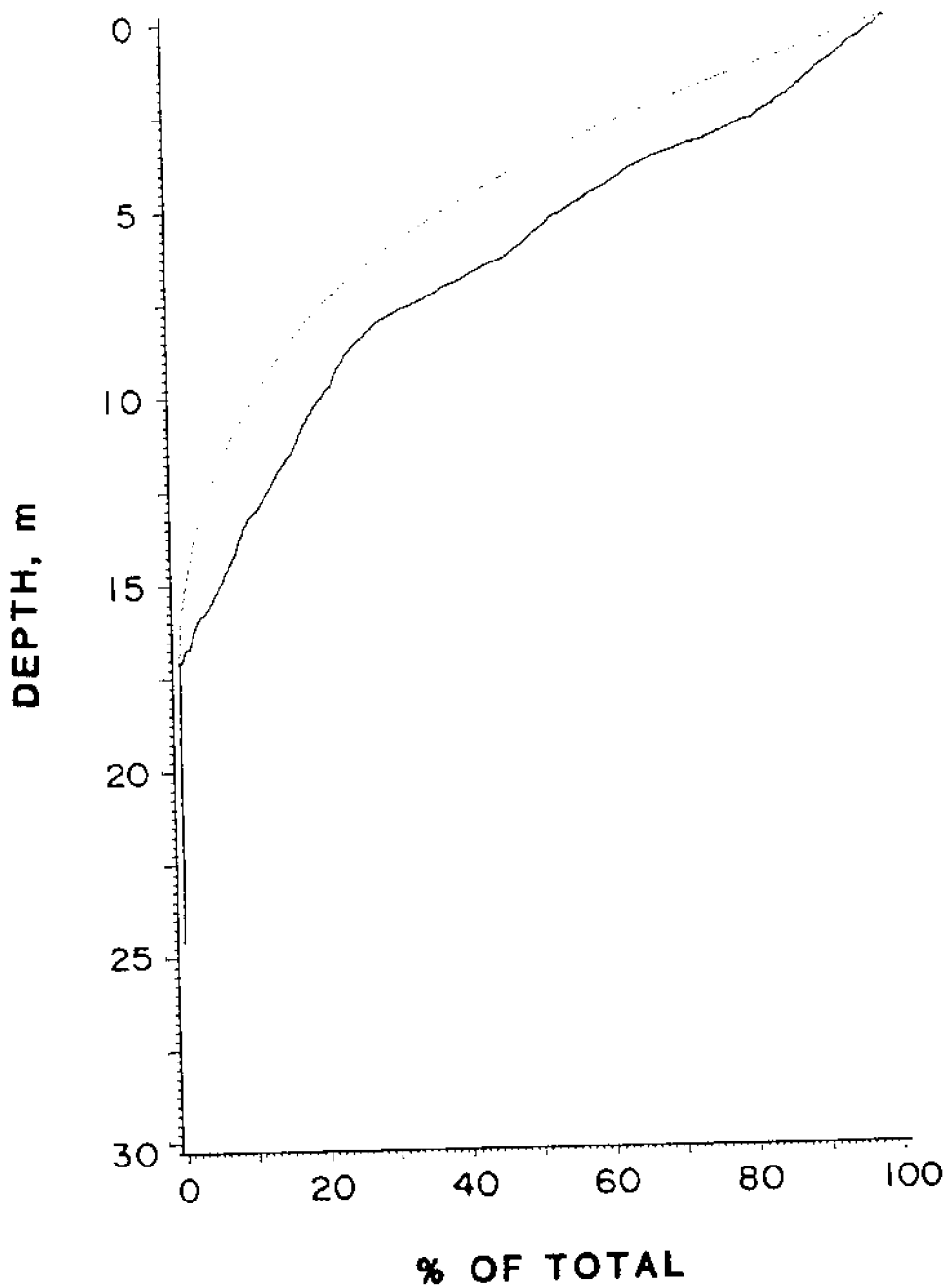


Figure 9b. Hypsographic curve for the Sakonnet River (Element 10). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 9b. The area and volume of the Sakonnet River (Element 10, Figure 1) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0- 1	3.561	49.245	0	50.968	100.000	331.537	100.000
1- 2	3.252	45.736	1	47.406	93.010	282.292	85.150
2- 3	4.671	42.048	2	44.155	86.630	236.556	71.350
3- 4	6.916	35.928	3	39.484	77.470	194.507	58.670
4- 5	4.103	30.582	4	32.568	63.900	158.579	47.830
5- 6	3.510	26.517	5	28.464	55.850	127.997	38.610
6- 7	4.877	22.574	6	24.955	48.960	101.480	30.610
7- 8	5.406	17.338	7	20.077	39.390	78.906	23.800
8- 9	2.581	13.280	8	14.671	28.780	61.568	18.570
9-10	1.535	11.334	9	12.090	23.720	48.288	14.560
10-11	1.690	9.642	10	10.555	20.710	36.954	11.150
11-12	1.445	8.222	11	8.864	17.390	27.312	8.240
12-13	1.587	6.646	12	7.419	14.560	19.091	5.760
13-14	1.497	4.923	13	5.832	11.440	12.444	3.750
14-15	1.174	3.801	14	4.335	8.510	7.521	2.270
15-16	1.677	2.394	15	3.161	6.200	3.720	1.120
16-17	1.187	0.923	16	1.484	2.910	1.326	0.400
17-18	0.206	0.111	17	0.297	0.582	0.403	0.122
18-19	0.013	0.088	18	0.090	0.177	0.292	0.088
19-20	0.026	0.054	19	0.077	0.152	0.204	0.062
20-21	0.000	0.052	20	0.052	0.101	0.150	0.045
21-22	0.026	0.036	21	0.052	0.101	0.098	0.030
22-23	0.000	0.026	22	0.026	0.051	0.063	0.019
23-24	0.000	0.026	23	0.026	0.051	0.037	0.011
24-25	0.026	0.011	24	0.026	0.051	0.011	0.003

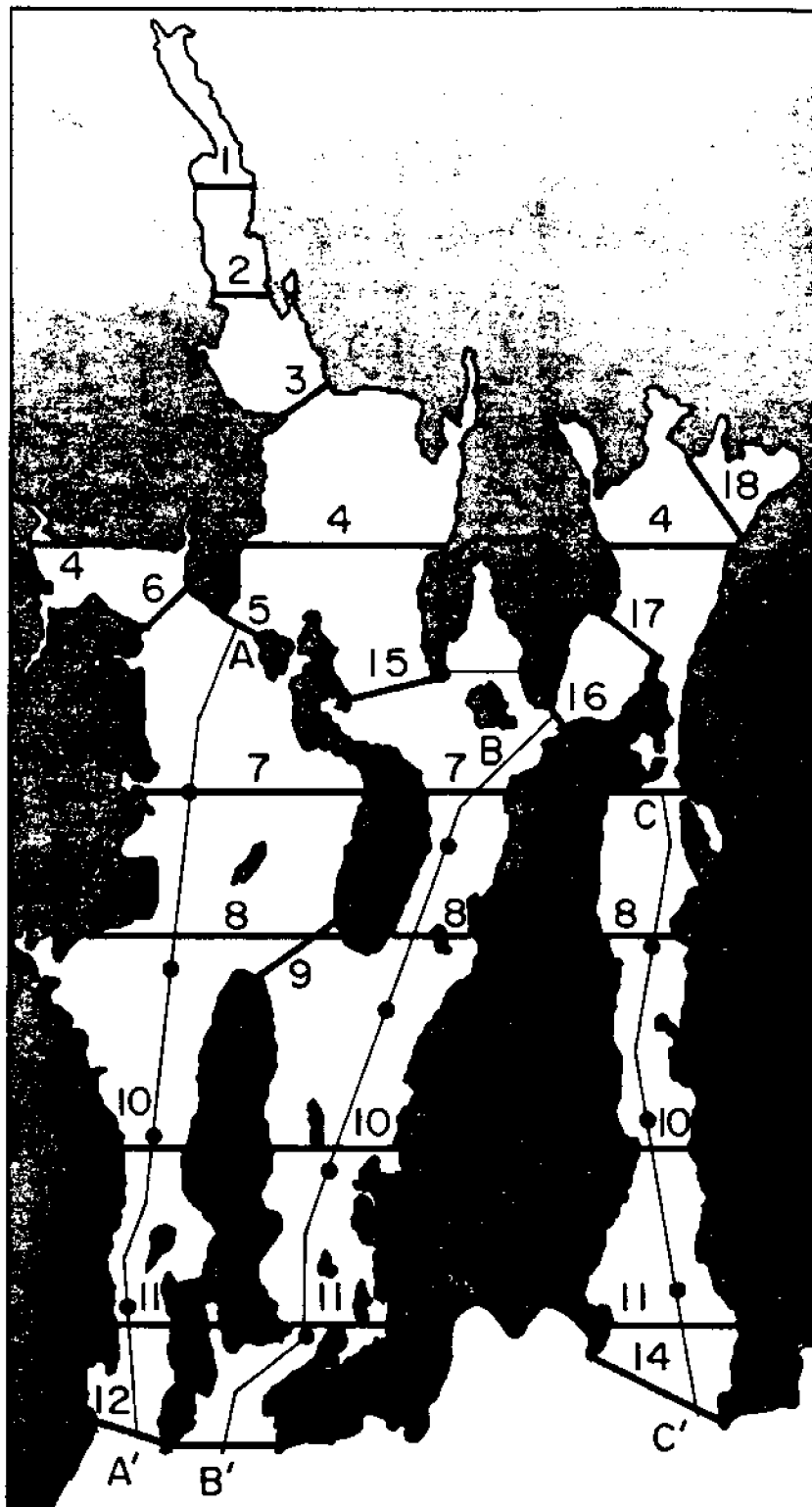


Figure 10. Narragansett Bay cross-sections and bathymetric profiles. Cross sections are numbered 1-18 (note that numbers 4, 7, 8, 10, and 11 are bay-wide cross-sections). Bathymetric profiles are labeled AA', BB', and CC'. Solid circles are placed every 5 km along the profiles beginning at the northern end. The outlined portion in the map center is Bristol Harbor (a detailed contour map of this area is shown in Figure 4).

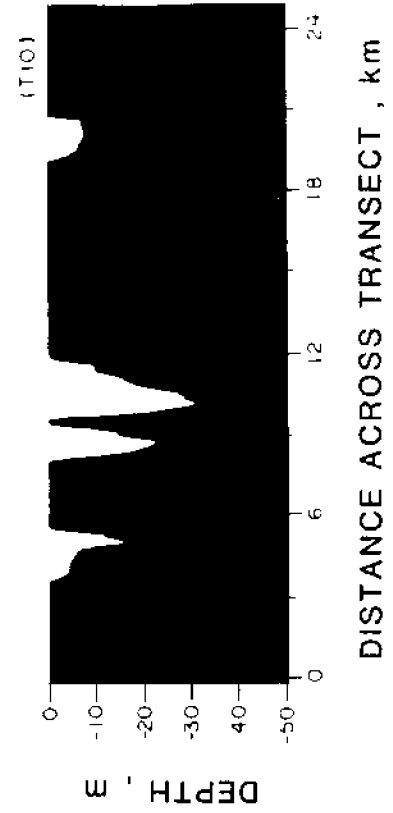
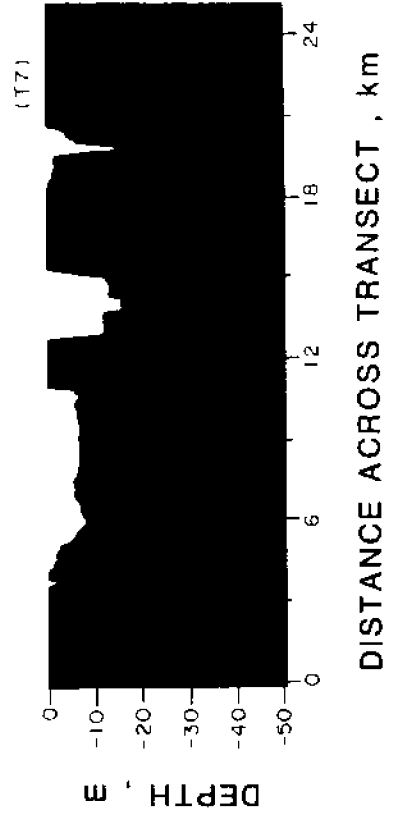
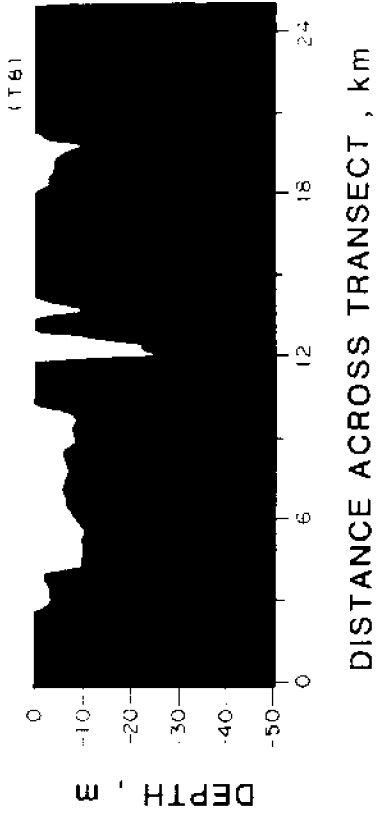
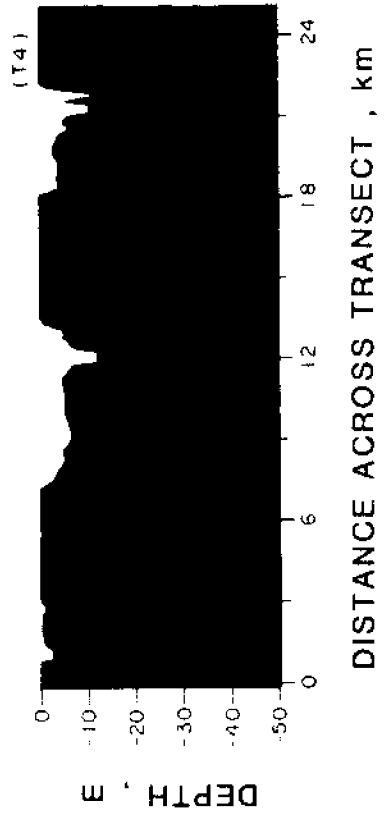
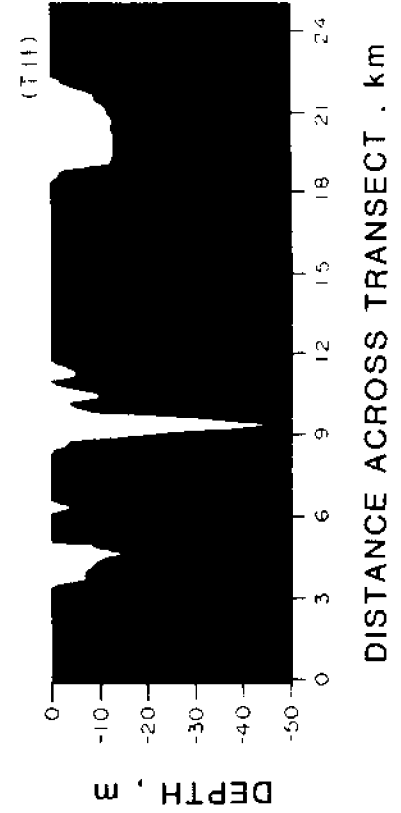


Figure 11. Cross-sections across whole bay. Transects 4, 7, 8, 10, 11 (see Figure 10). Vertical exaggeration 175X.



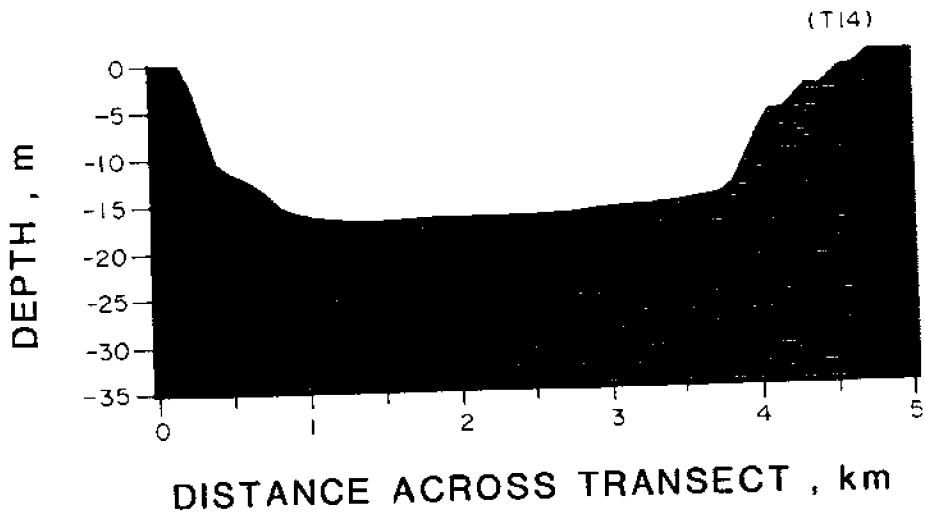
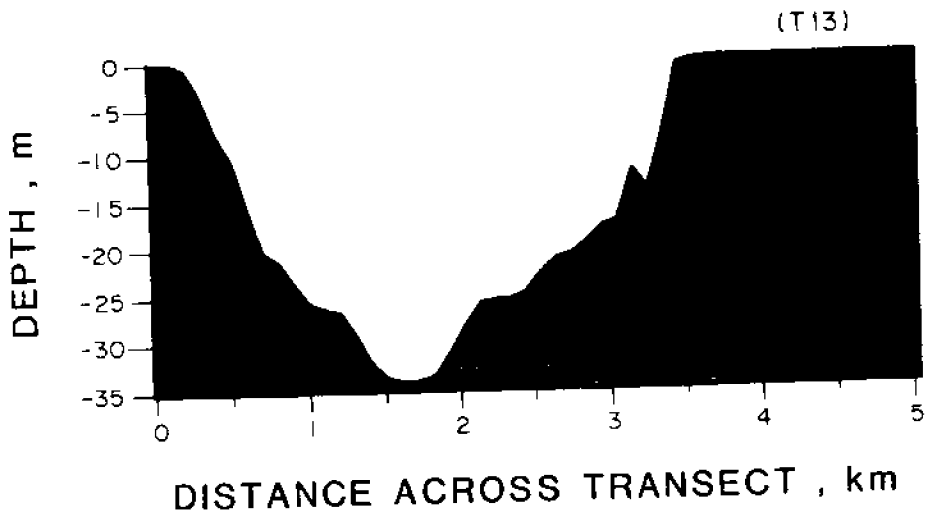
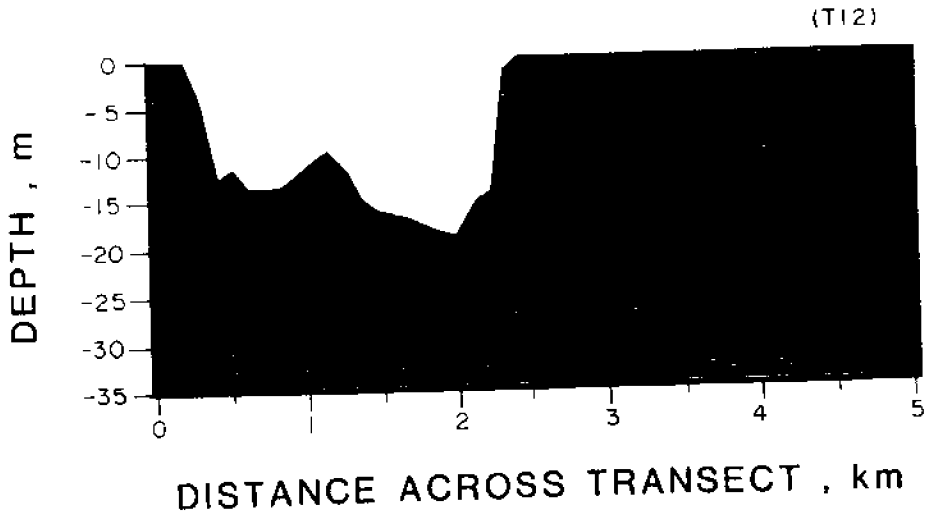


Figure 12. Cross-sections across mouth of the bay. Transects 12,13,14 (see Figure 10). Vertical exaggeration 60X.

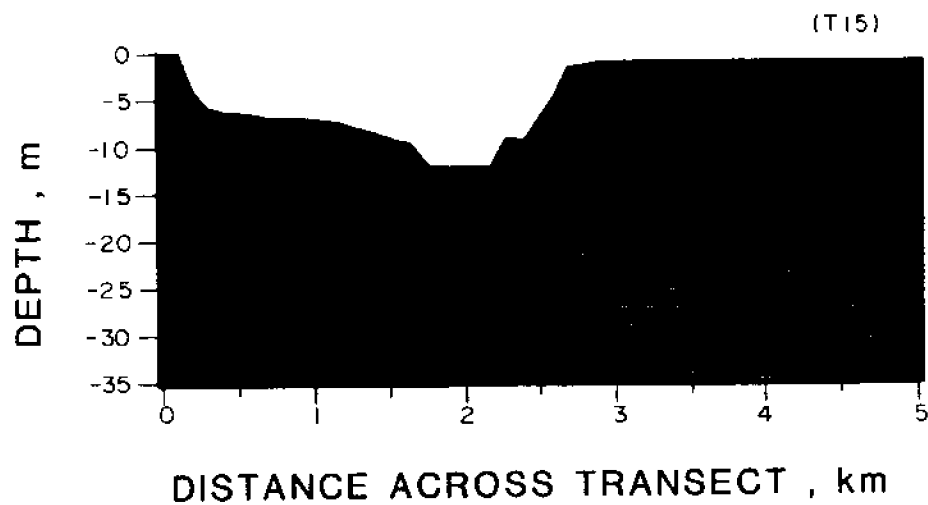
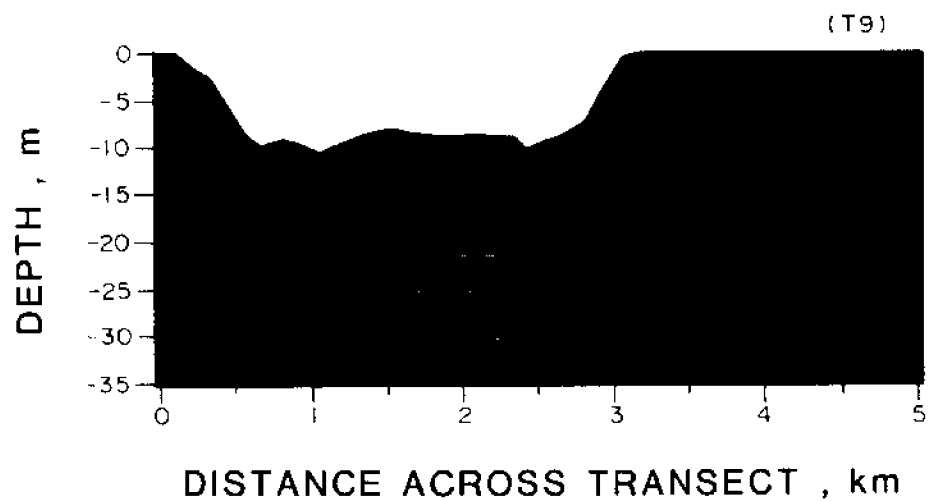
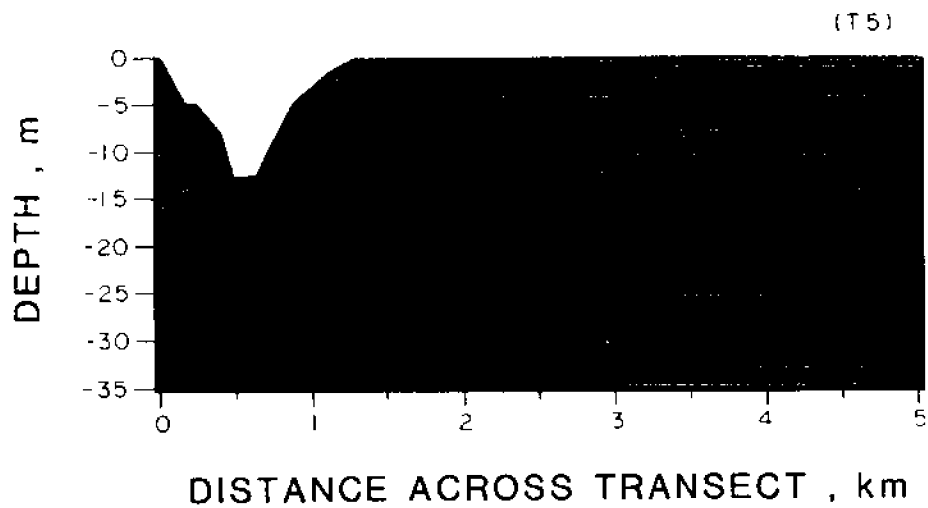


Figure 13. Cross-sections separating East and West Passages. Transects 5,9,15 (see Figure 10). Vertical exaggeration 60X.

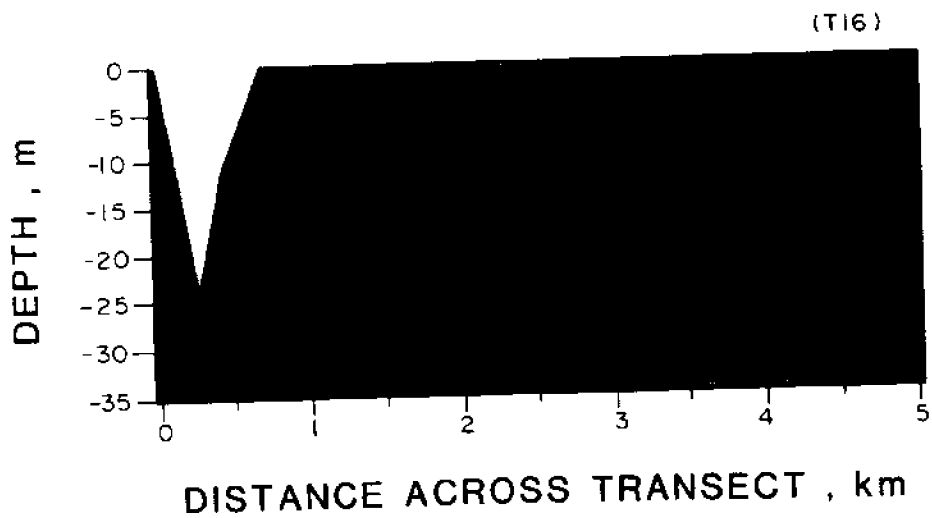
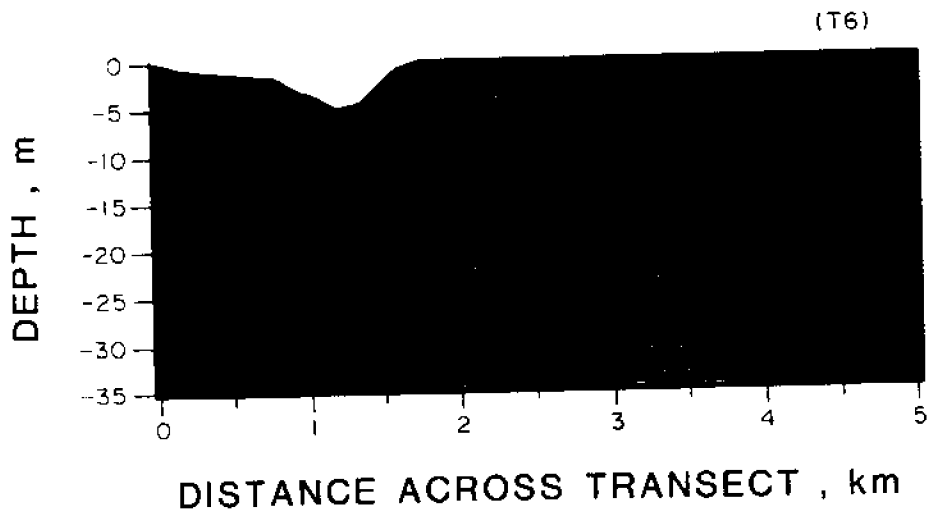
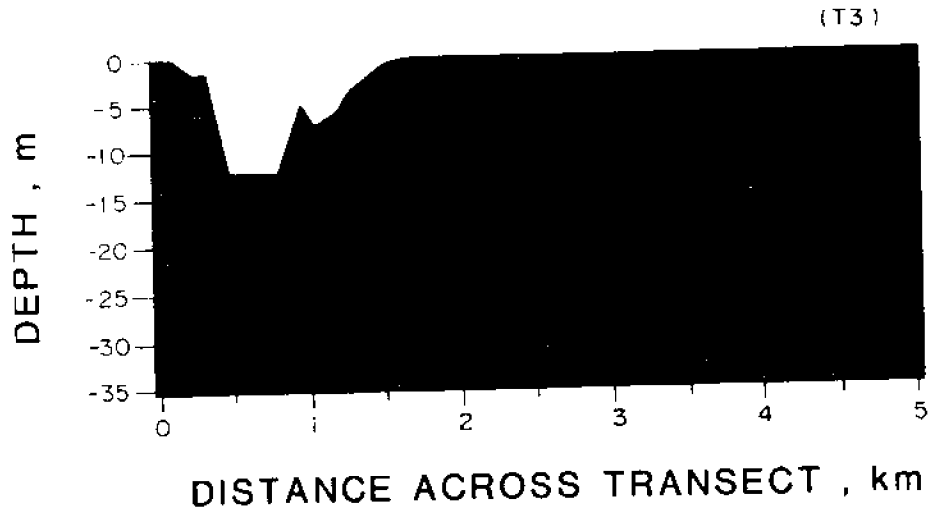


Figure 14. Cross-sections across the mouths of the Providence River, Greenwich Bay, and Mount Hope Bay. Transects 3,6,16 (see figure 10). Vertical exaggeration 60X.

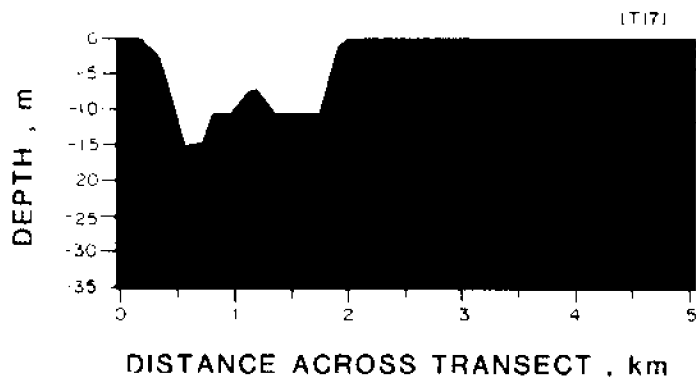
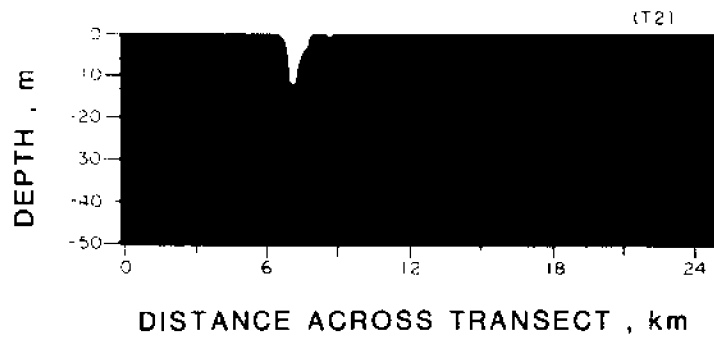
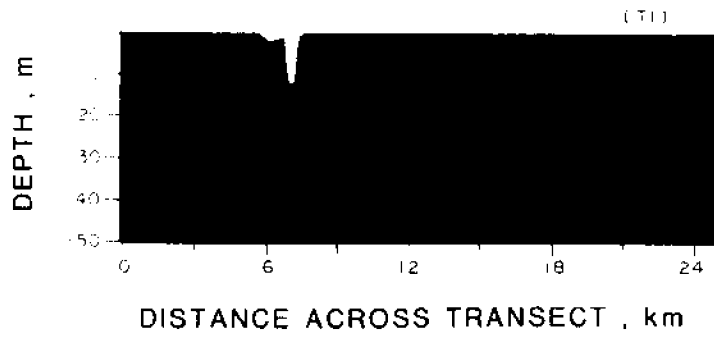


Figure 15. Cross-sections across the Providence River and Mount Hope Bay. Transects 1,2,17,18 (see Figure 10). Vertical exaggeration 175X for transects 1 and 2, 60X for 17 and 18.



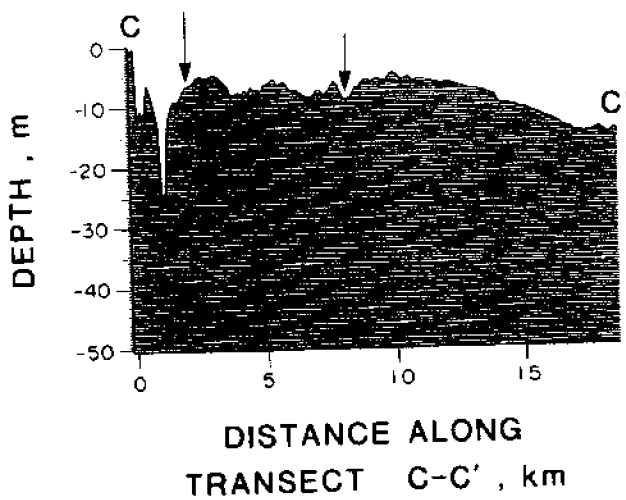
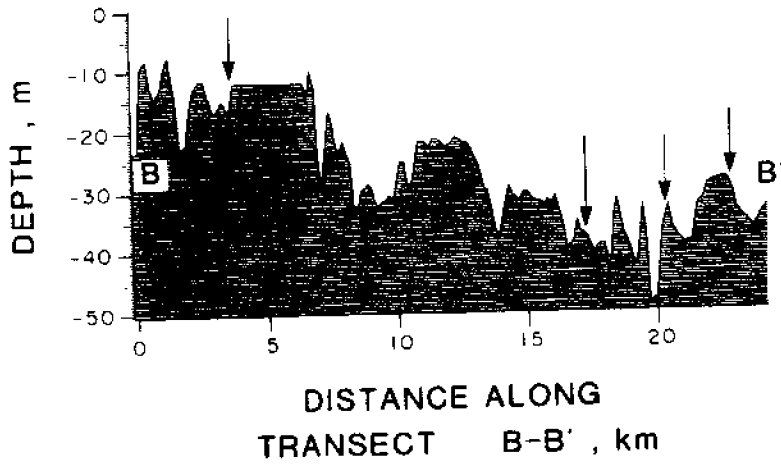
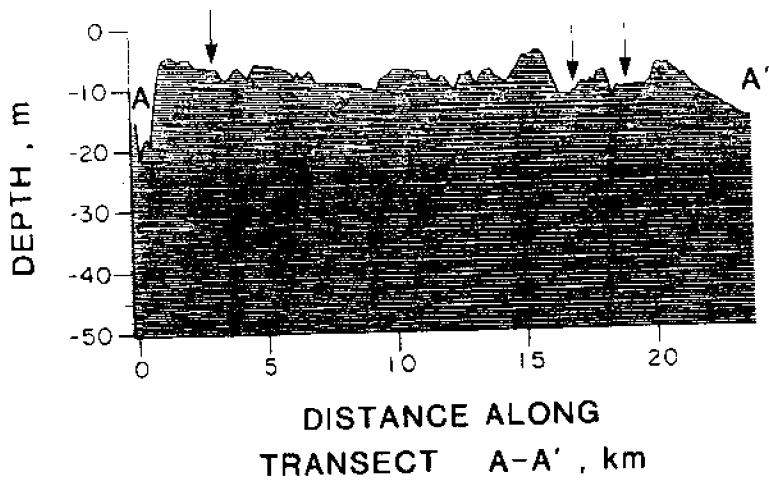


Figure 16. Bathymetric profiles along major passages. The West Passage (AA'), the East Passage (BB'), and the Sakonnet River (CC'). Vertical exaggeration 235X. Arrows point to positions along the transect where a change in direction occurs (see Figure 10). Note that in profile BB' the transect intersected a dredged channel at about 5 km.

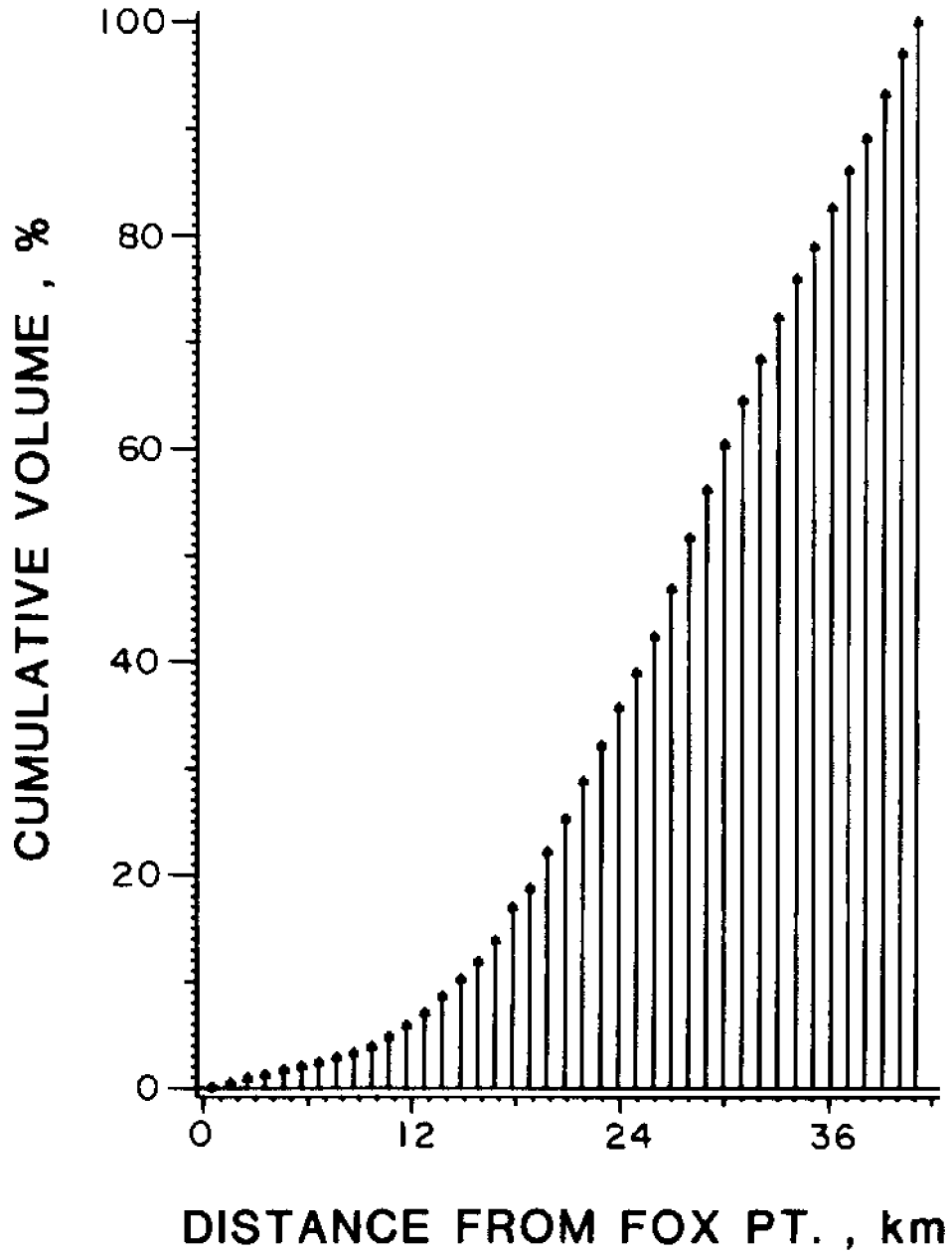


Figure 17a. Cumulative percent of the total volume of Narragansett Bay, excluding Mount Hope Bay and the Sakonnet River (Elements 1-8), with increasing distance from Fox Point at the head of the Providence River.

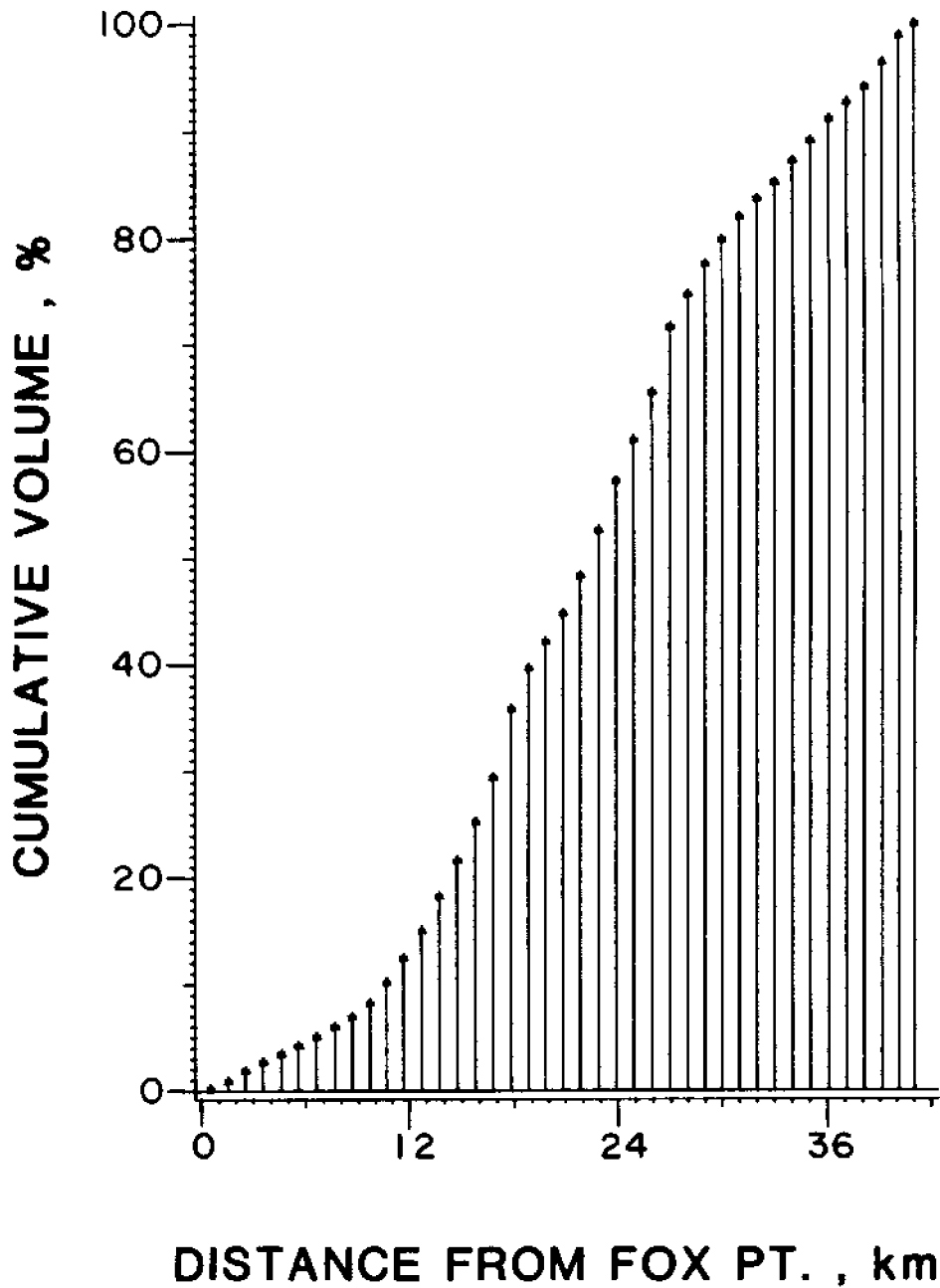


Figure 17b. Cumulative percent of the total volume of the Providence River, Upper Bay and West Passage (Elements 1-2, 4-5), with increasing distance from Fox Point at the head of the Providence River.

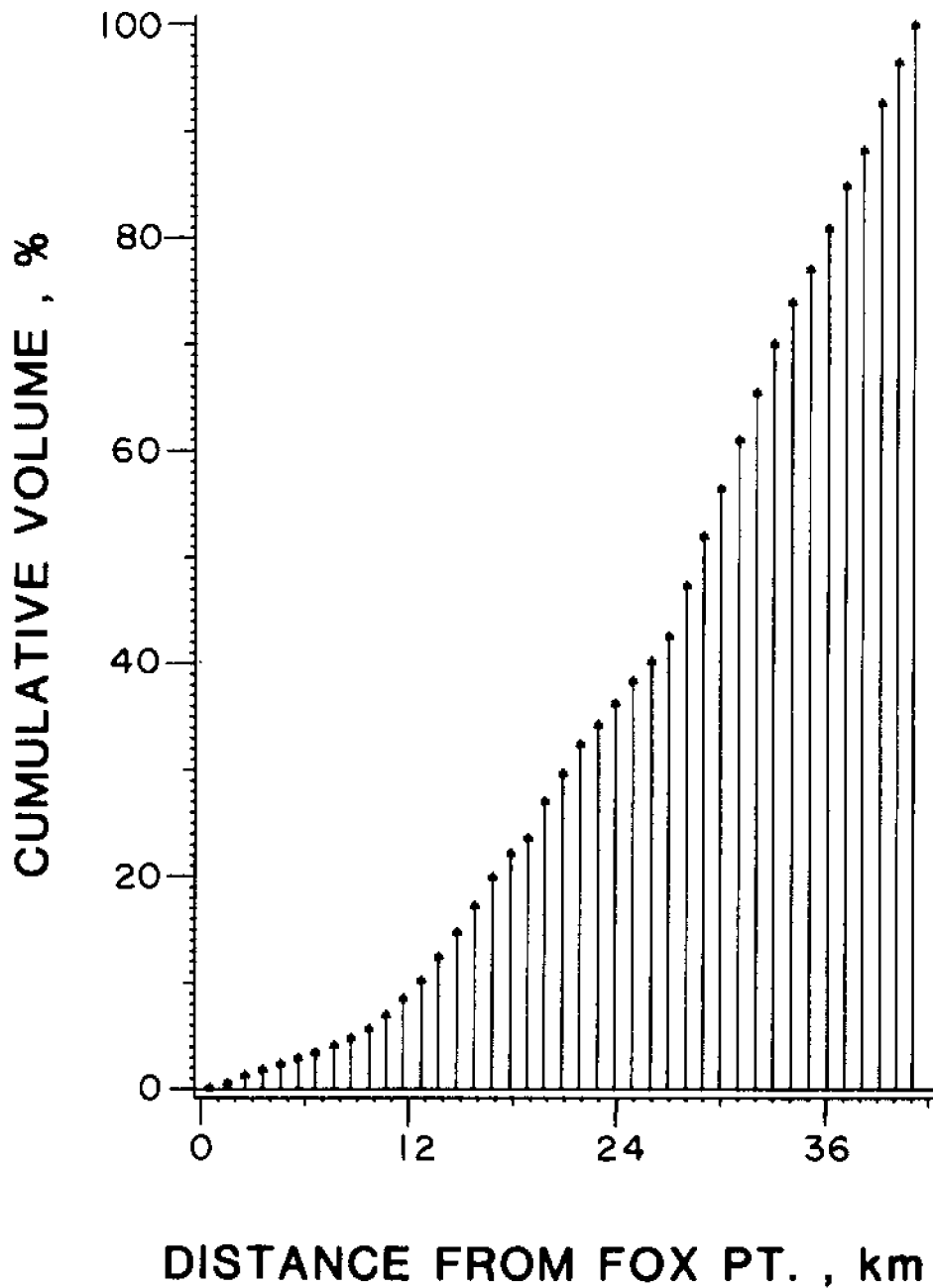


Figure 17c. Cumulative percent of the total volume of the Providence River, Upper Bay and East Passage (Elements 1-2, 6-8), with increasing distance from Fox Point at the head of the Providence River.

Table 10a. Volume and cross-sectional area of the Providence River, Upper Bay, Greenwich Bay, and the West Passage of Narragansett Bay (Elements 1-5) with increasing distance from Fox Point at the head of the Providence River. The cross-sectional area is the segment volume divided by the segment width. Elements and segments are shown in Figure 1. All of the volume of Greenwich Bay (Element 3) has been included in Segment 18. The West Passage has been separated from the East at Segment 27 along the boundary between Elements 4 and 7, shown in Figure 1. The cumulative volume of the transect is shown graphically in Figure 17b.

Segment #	Distance from Fox Point to Mid-Segment m	Segment Volume $m^3 \times 10^6$	Cumulative Volume $m^3 \times 10^6$	Cross-Sectional Area $m^2$
1	508	1.670	1.670	1643.6
2	1524	7.169	8.839	7056.0
3	2540	10.170	19.009	10010.3
4	3556	8.015	27.024	7888.9
5	4572	8.112	35.136	7984.4
6	5588	7.588	42.725	7468.6
7	6604	8.567	51.292	8432.2
8	7620	9.738	61.029	9584.4
9	8636	9.110	70.140	8966.8
10	9652	13.186	83.325	12977.9
11	10668	19.817	103.143	19505.3
12	11684	22.740	125.882	22381.7
13	12700	25.823	151.706	25416.4
14	13716	32.525	184.230	32012.4
15	14732	34.247	218.477	33707.5
16	15748	36.764	255.241	36185.1
17	16764	42.039	297.280	41376.9
18	17780	65.373	362.652	64343.2
19	18796	38.986	401.638	38372.0
20	19812	24.959	426.597	24566.0
21	20828	26.817	453.414	26394.7
22	21844	35.233	488.648	34678.6
23	22860	43.866	532.514	43175.7
24	23876	46.460	578.975	45728.8
25	24892	38.931	617.905	38317.4
26	25908	44.882	662.787	44174.9
27	26924	61.993	724.780	61016.3
28	27940	30.755	755.535	30270.8
29	28956	28.989	784.524	28532.8
30	29972	23.831	808.355	23455.9
31	30988	21.517	829.872	21178.3
32	32004	16.562	846.435	16301.3
33	33020	15.797	862.232	15548.6
34	34036	20.561	882.793	20237.4
35	35052	18.291	901.084	18002.8
36	36068	20.871	921.955	20542.0
37	37084	15.268	937.222	15027.3
38	38100	14.875	952.097	14640.8
39	39116	22.612	974.709	22255.9
40	40132	25.661	1000.371	25257.1
41	41021	11.188	1011.559	14682.9

Table 10b. Volume and cross-sectional area of the Providence River, Upper Bay, and the East Passage of Narragansett Bay (Elements 1-2, 6-8) with increasing distance from Fox Point at the head of the Providence River. The cross-sectional area is the segment volume divided by the segment width. Elements and segments are shown in Figure 1. All of the volume of Bristol Harbor has been included in Segment 20. The East Passage has been separated from the West at Segment 27 along the boundary between Elements 4 and 7, shown in Figure 1. The cumulative volume of the transect is shown graphically in Figure 17c.

Segment #	Distance from Fox Point to Mid-Segment m	Segment Volume $m^3 \times 10^6$	Cumulative Volume $m^3 \times 10^6$	Cross-Sectional Area $m^2$
1	508	1.670	1.670	1643.6
2	1524	7.169	8.839	7056.0
3	2540	10.170	19.009	10010.3
4	3556	8.015	27.024	7888.9
5	4572	8.112	35.136	7984.4
6	5588	7.588	42.725	7468.6
7	6604	8.567	51.292	8432.2
8	7620	9.738	61.029	9584.4
9	8636	9.110	70.140	8966.8
10	9652	13.186	83.325	12977.9
11	10668	19.817	103.143	19505.3
12	11684	22.740	125.882	22381.7
13	12700	25.823	151.706	25416.4
14	13716	32.525	184.230	32012.4
15	14732	34.247	218.477	33707.5
16	15748	36.764	255.241	36185.1
17	16764	40.268	295.509	39633.8
18	17780	33.586	329.095	33057.3
19	18796	22.857	351.952	22497.3
20	19812	49.443	401.395	48664.4
21	20828	38.320	439.715	37716.6
22	21844	40.430	480.145	39792.9
23	22860	27.119	507.264	26692.4
24	23876	30.148	537.412	29673.3
25	24892	31.272	568.685	30779.6
26	25908	27.319	596.003	26888.6
27	26924	34.707	630.710	34160.2
28	27940	71.227	701.937	70105.3
29	28956	68.151	770.088	67077.7
30	29972	66.528	836.616	65479.9
31	30988	66.747	903.363	65696.0
32	32004	66.099	969.462	65058.4
33	33020	68.039	1037.502	66968.0
34	34036	57.506	1095.007	56600.0
35	35052	46.832	1141.840	46094.9
36	36068	56.845	1198.684	55949.6
37	37084	59.395	1258.079	58459.8
38	38100	49.019	1307.098	48246.9
39	39116	64.970	1372.068	63947.0
40	40132	56.216	1428.285	55330.9
41	41021	52.257	1480.542	68579.2

Table 10c. Volume and cross-sectional area of Mount Hope Bay and the Sakonnet River (Elements 9 and 10) with increasing distance from the head of each element. The cross-sectional area is the segment volume divided by the segment width. Elements and segments are shown in Figure 1.

Segment #	Distance from Head of the Element to Mid-Segment m	Segment Volume $m^3 \times 10^6$	Cumulative Volume $m^3 \times 10^6$	Cross-Sectional Area $m^2$
<b>Mount Hope Bay</b>				
11	190.5	0.153	0.153	402.0
12	889.0	3.483	3.636	3428.4
13	1905.0	15.520	19.157	15275.9
14	2921.0	27.473	46.630	27040.6
15	3937.0	23.169	69.799	22804.1
16	4953.0	21.125	90.924	20792.6
17	5969.0	21.500	112.425	21161.9
18	6985.0	31.273	143.698	30780.4
19	8001.0	30.063	173.761	29590.0
20	9017.0	24.574	198.335	24187.4
21	9842.5	3.364	201.699	5297.4
<b>Sakonnet River</b>				
21	444.5	3.872	3.872	4355.7
22	1397.0	4.735	8.607	4660.4
23	2413.0	14.355	22.962	14129.1
24	3429.0	10.688	33.650	10519.7
25	4445.0	10.066	43.716	9907.0
26	5461.0	10.138	53.853	9977.9
27	6477.0	9.773	63.627	9619.5
28	7493.0	11.401	75.028	11221.3
29	8509.0	9.725	84.752	9571.6
30	9525.0	8.580	93.332	8444.6
31	10541.0	11.271	104.603	11093.4
32	11557.0	11.939	116.542	11750.5
33	12573.0	11.099	127.640	10923.9
34	13589.0	14.446	142.086	14218.2
35	14605.0	18.494	160.580	18202.7
36	15621.0	24.478	185.058	24092.3
37	16637.0	32.318	217.376	31809.2
38	17653.0	46.294	263.670	45564.7
39	18669.0	52.312	315.981	51487.7
40	19685.0	15.553	331.534	15307.8
41	20256.5	0.003	331.537	24.4

Table 11a. The area and volume of the combined Providence and Seekonk Rivers (Elements 1-4, detailed analysis; Figure 3) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> ×10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> ×10 <sup>6</sup>	% of Total Volume
0- 1	7.510	20.380	0	24.128	100.000	88.730	100.000
1- 2	4.501	14.165	1	16.618	68.870	68.192	76.850
2- 3	2.406	10.718	2	12.117	50.220	54.027	60.890
3- 4	1.935	8.759	3	9.710	40.250	43.310	48.810
4- 5	1.613	7.016	4	7.775	32.220	34.550	38.940
5- 6	1.075	5.624	5	6.162	25.540	27.535	31.030
6- 7	0.865	4.647	6	5.087	21.080	21.910	24.690
7- 8	0.654	3.851	7	4.222	17.500	17.263	19.460
8- 9	0.315	3.381	8	3.568	14.790	13.412	15.120
9-10	0.101	3.194	9	3.252	13.480	10.031	11.310
10-11	0.034	3.129	10	3.152	13.060	6.837	7.710
11-12	0.020	3.107	11	3.118	12.920	3.709	4.180
12-13	3.090	0.595	12	3.098	12.840	0.602	0.678
13-14	0.004	0.005	13	0.007	0.030	0.007	0.007
14-15	0.003	0.002	14	0.003	0.013	0.002	0.002

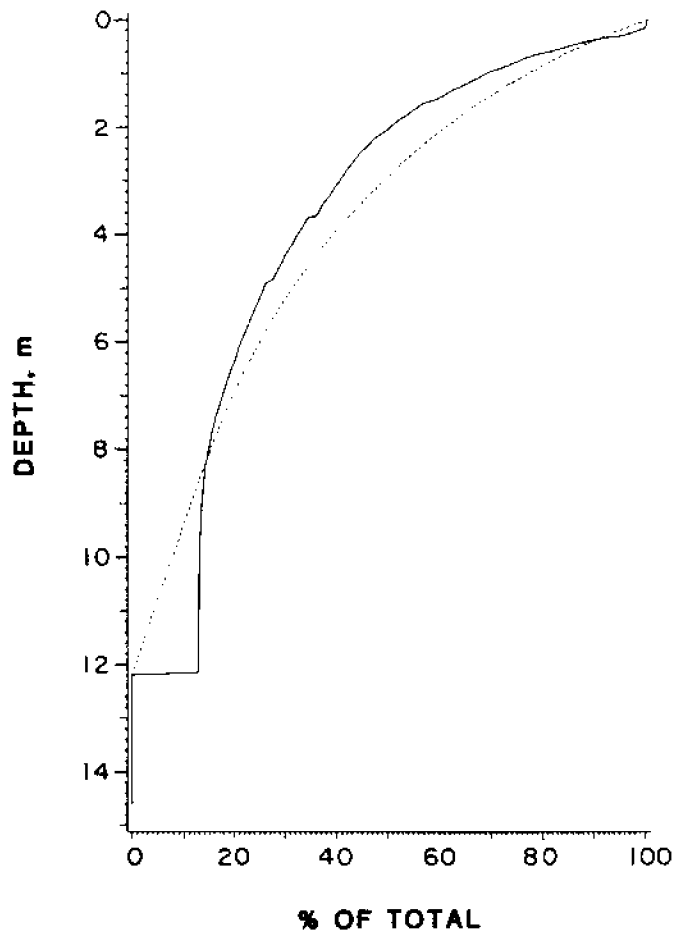


Figure 18a. Hypsographic curve for the combined Providence and Seekonk Rivers (Elements 1-4, detailed analysis). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.



Table 11b. The area and volume of the Seekonk River (Element 1, detailed analysis; Figure 3) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> ×10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> ×10 <sup>6</sup>	% of Total Volume
0-1	2.034	1.660	0	2.806	100.000	3.631	100.000
1-2	0.234	0.608	1	0.773	27.530	1.970	54.270
2-3	0.054	0.511	2	0.539	19.200	1.363	37.530
3-4	0.066	0.455	3	0.485	17.270	0.852	23.460
4-5	0.346	0.347	4	0.419	14.910	0.397	10.930
5-6	0.053	0.042	5	0.073	2.590	0.050	1.380
6-7	0.018	0.008	6	0.019	0.690	0.008	0.219
7-8	0.002	0.000	7	0.002	0.057	0.000	0.001

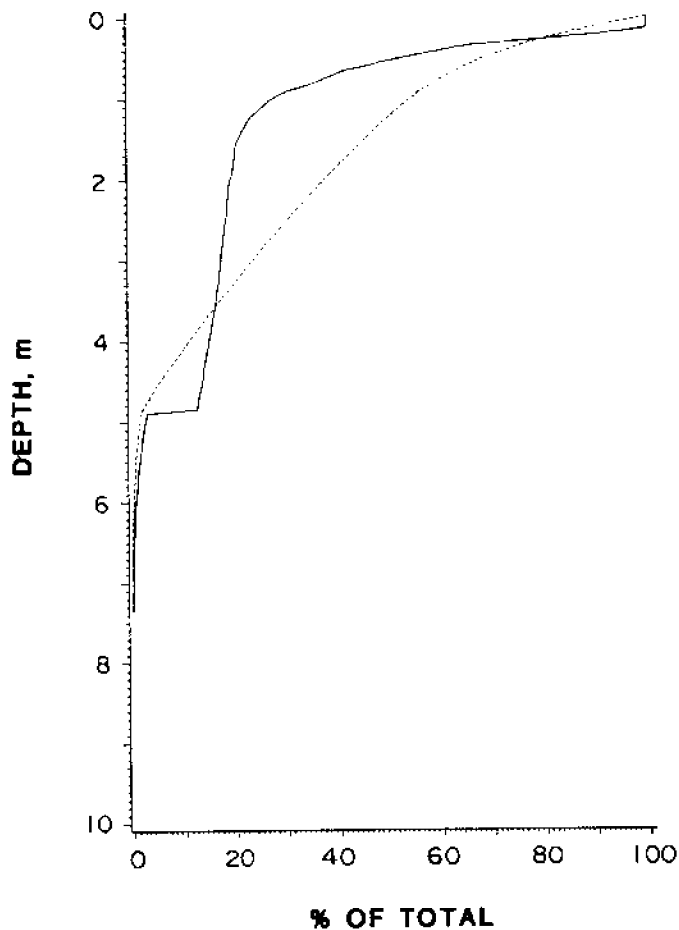


Figure 18b. Hypsographic curve for the Seekonk River (Element 1, detailed analysis). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 11c. The area and volume of the Providence River (Elements 2-4, detailed analysis; Figure 3) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of total Volume
0- 1	5.477	18.878	0	21.322	100.000	85.100	100.000
1- 2	4.267	13.557	1	15.845	74.314	66.221	77.816
2- 3	2.352	10.207	2	11.578	54.302	52.665	61.886
3- 4	1.869	8.305	3	9.226	43.269	42.458	49.892
4- 5	1.267	6.669	4	7.356	34.502	34.153	40.133
5- 6	1.022	5.582	5	6.090	28.560	27.484	32.297
6- 7	0.848	4.639	6	5.068	23.768	21.902	25.737
7- 8	0.652	3.850	7	4.220	19.793	17.263	20.285
8- 9	0.315	3.381	8	3.568	16.733	13.412	15.761
9-10	0.101	3.194	9	3.252	15.254	10.031	11.788
10-11	0.034	3.129	10	3.152	14.781	6.837	8.035
11-12	0.020	3.107	11	3.118	14.622	3.709	4.358
12-13	3.090	0.595	12	3.098	14.528	0.602	0.707
13-14	0.004	0.005	13	0.007	0.034	0.007	0.008
14-15	0.003	0.002	14	0.003	0.015	0.002	0.002

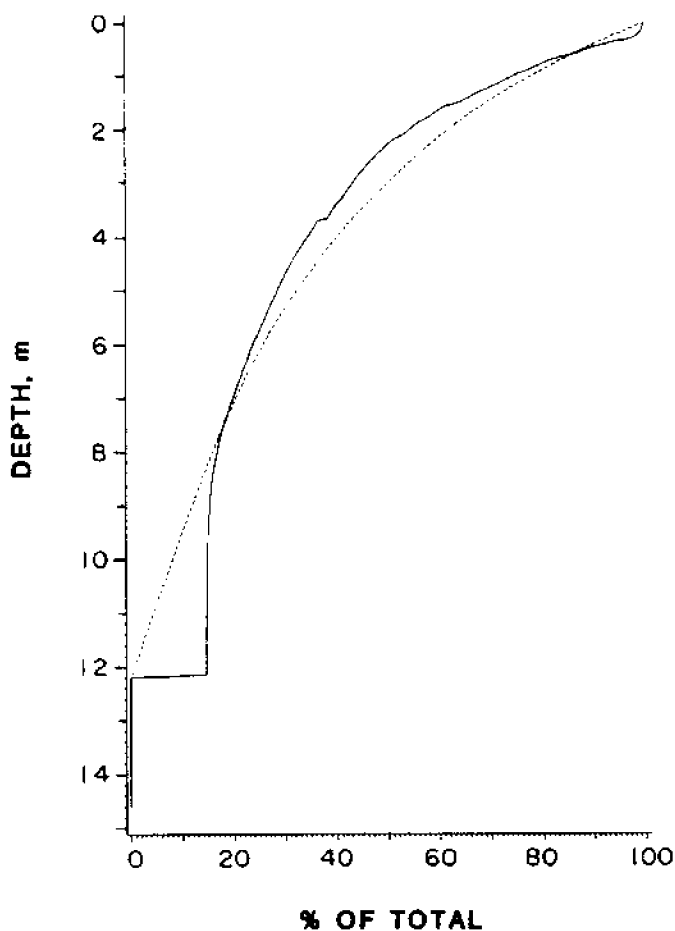


Figure 18c. Hypsographic curve for the Providence River (Elements 2-4, detailed analysis). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 11d. The area and volume of the Fox Point Reach (Element 2, detailed analysis; Figure 3) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0- 1	0.592	2.769	0	3.000	100.000	21.095	100.000
1- 2	0.277	2.241	1	2.408	80.270	18.325	86.870
2- 3	0.169	2.029	2	2.131	71.020	16.084	76.250
3- 4	0.132	1.897	3	1.961	65.380	14.056	66.630
4- 5	0.146	1.757	4	1.829	60.970	12.159	57.640
5- 6	0.162	1.604	5	1.683	56.100	10.402	49.310
6- 7	0.077	1.472	6	1.521	50.700	8.798	41.710
7- 8	0.023	1.434	7	1.444	48.150	7.326	34.730
8- 9	0.013	1.410	8	1.421	47.370	5.893	27.940
9-10	0.002	1.407	9	1.408	46.940	4.483	21.250
10-11	0.001	1.405	10	1.406	46.850	3.077	14.590
11-12	0.000	1.405	11	1.405	46.830	1.672	7.930
12-13	1.405	0.267	12	1.405	46.830	0.267	1.270
13-14	0.000	0.000	13	0.000	0.000	0.000	0.000

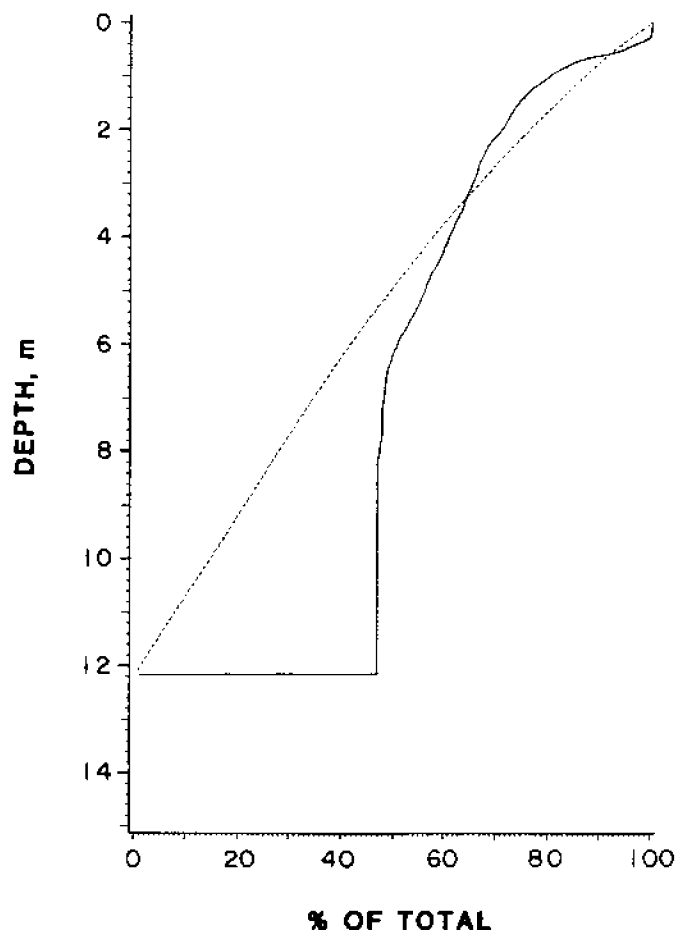


Figure 18d. Hypsographic curve for the Fox Point Reach (Element 2, detailed analysis). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 11e. The area and volume of the Sabin Point Reach (Element 3, detailed analysis; Figure 3) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> ×10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> ×10 <sup>6</sup>	% of Total Volume
0- 1	1.687	7.867	0	8.535	100.000	28.926	100.000
1- 2	2.632	5.551	1	6.848	80.230	21.058	72.800
2- 3	1.276	3.413	2	4.216	49.400	15.507	53.610
3- 4	0.952	2.498	3	2.940	34.450	12.094	41.810
4- 5	0.435	1.750	4	1.988	23.290	9.596	33.180
5- 6	0.265	1.406	5	1.553	18.200	7.847	27.130
6- 7	0.153	1.203	6	1.288	15.090	6.441	22.270
7- 8	0.119	1.060	7	1.135	13.290	5.237	18.110
8- 9	0.006	1.011	8	1.016	11.900	4.177	14.440
9-10	0.010	1.005	9	1.010	11.830	3.166	10.940
10-11	0.012	0.991	10	0.999	11.710	2.161	7.470
11-12	0.006	0.984	11	0.987	11.560	1.170	4.050
12-13	0.981	0.186	12	0.981	11.500	0.186	0.645
13-14	0.000	0.000	13	0.000	0.000	0.000	0.000

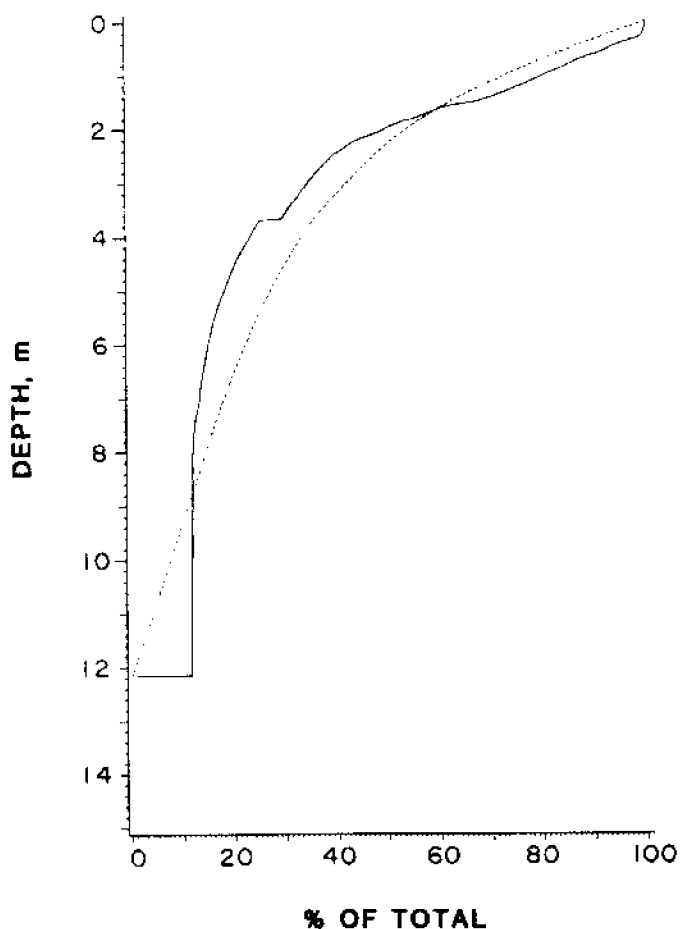


Figure 18e. Hypsographic curve for the Sabin Point Reach (Element 3, detailed analysis). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 11f. The area and volume of the Nyatt Point Reach (Element 4, detailed analysis; Figure 3) at various depth intervals and the total area and volume below each 1 m increment.

Depth Interval m	Area km <sup>2</sup>	Volume m <sup>3</sup> x10 <sup>6</sup>	Depth m	Area Below Depth		Volume Below Depth	
				km <sup>2</sup>	% of Total Area	m <sup>3</sup> x10 <sup>6</sup>	% of Total Volume
0- 1	3.198	8.241	0	9.786	100.000	35.079	100.000
1- 2	1.357	5.765	1	6.589	67.330	26.838	76.510
2- 3	0.907	4.765	2	5.231	53.460	21.073	60.070
3- 4	0.785	3.910	3	4.324	44.190	16.308	46.490
4- 5	0.686	3.163	4	3.540	36.170	12.398	35.340
5- 6	0.594	2.572	5	2.853	29.160	9.235	26.330
6- 7	0.618	1.964	6	2.259	23.080	6.663	18.990
7- 8	0.510	1.357	7	1.641	16.770	4.699	13.390
8- 9	0.296	0.960	8	1.131	11.550	3.342	9.530
9-10	0.088	0.783	9	0.835	8.530	2.382	6.790
10-11	0.021	0.733	10	0.747	7.630	1.599	4.560
11-12	0.015	0.718	11	0.726	7.420	0.867	2.470
12-13	0.704	0.142	12	0.711	7.270	0.150	0.424
13-14	0.004	0.005	13	0.007	0.074	0.007	0.019
14-15	0.003	0.002	14	0.003	0.033	0.002	0.004

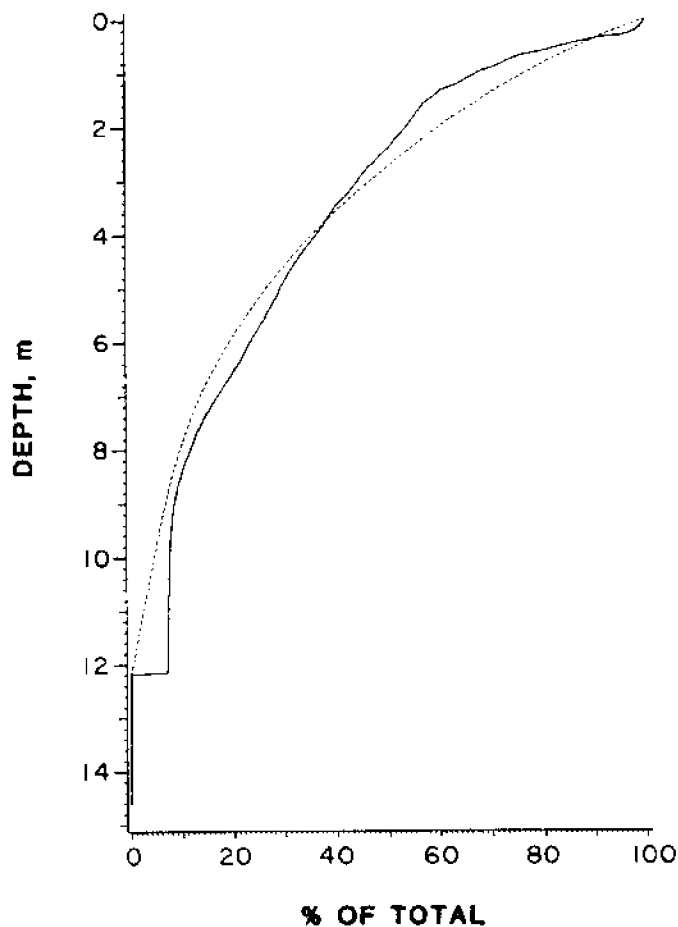


Figure 18f. Hypsographic curve for the Nyatt Point Reach (Element 4, detailed analysis). Percentage of total area (solid line) and total volume (dashed line) below the specified depth.

Table 12a. Volume and cross-sectional area of the combined Providence and Seekonk Rivers (Elements 1-4, detailed version) with increasing distance from the dam in Pawtucket at the head of the Seekonk River. The cross-sectional area is the segment volume divided by the segment width. Elements and segments are shown in Figure 3. The cumulative volume of the transect is shown graphically in Figure 19a.

Segment #	Distance from Pawtucket to Mid-Segment m	Segment Volume $m^3 \times 10^6$	Cumulative Volume $m^3 \times 10^6$	Cross-Sectional Area $m^2$
1	508.0	0.169	0.169	166.1
2	1524.0	0.379	0.547	372.7
3	2540.0	0.460	1.008	452.9
4	3556.0	0.566	1.574	557.6
5	4572.0	0.628	2.202	618.1
6	5588.0	0.882	3.084	867.7
7	6604.0	3.118	6.201	3068.5
8	7620.0	7.223	13.424	7109.5
9	8636.0	7.167	20.591	7053.7
10	9652.0	5.024	25.615	4944.7
11	10668.0	6.347	31.962	6247.2
12	11684.0	5.746	37.708	5655.9
13	12700.0	6.696	44.404	6590.6
14	13716.0	6.984	51.389	6874.2
15	14732.0	7.190	58.578	7076.3
16	15748.0	12.560	71.138	12362.4
17	16764.0	16.762	87.901	16498.3
18	17462.5	0.830	88.730	2177.3

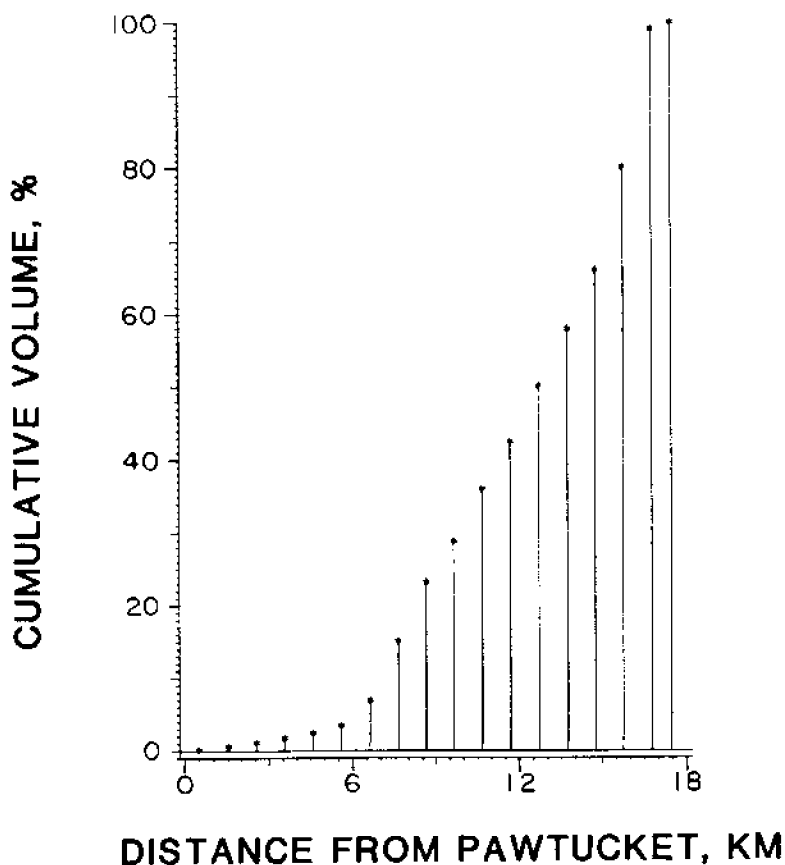


Figure 19a. Cumulative volume of the combined Seekonk and Providence Rivers below the first dam at Pawtucket.

Table 12b. Volume and cross-sectional area of the Seekonk River (Element 1, detailed version) with increasing distance from the dam in Pawtucket at the head of the Seekonk River. The cross-sectional area is the segment volume divided by the segment width. Elements and segments are shown in Figure 3. The cumulative volume of the transect is shown graphically in Figure 19b.

Segment #	Distance from Pawtucket to Mid-Segment m	Segment Volume $m^3 \times 10^6$	Cumulative Volume $m^3 \times 10^6$	Cross-Sectional Area $m^2$
1	508.0	0.169	0.169	166.1
2	1524.0	0.379	0.547	372.7
3	2540.0	0.460	1.008	452.9
4	3556.0	0.566	1.574	557.6
5	4572.0	0.628	2.202	618.1
6	5588.0	0.869	3.071	854.9
7	6413.5	0.560	3.631	881.8

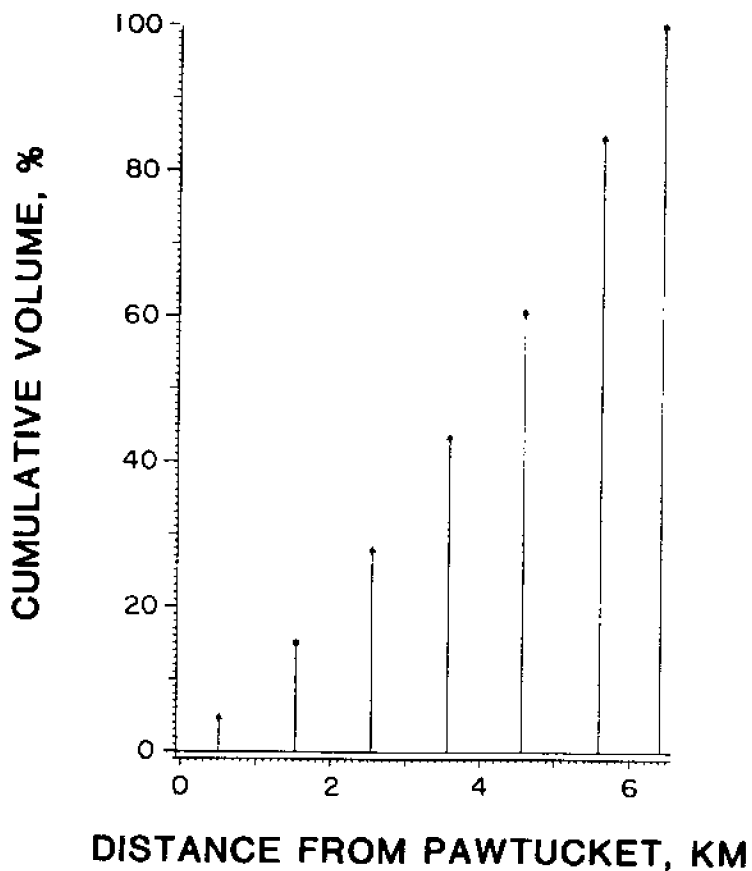


Figure 19b. Cumulative volume of the Seekonk River below the first dam at Pawtucket.

Table 12c. Volume and cross-sectional area of the Providence River (Elements 2-4, detailed version) with increasing distance from the head of the Providence River. The cross-sectional area is the segment volume divided by the segment width. Elements and segments are shown in Figure 3. The cumulative volume of the transect is shown graphically in Figure 19c.

Segment #	Distance from River Head to Mid-Segment m	Segment Volume $m^3 \times 10^6$	Cumulative Volume $m^3 \times 10^6$	Cross-Sectional Area $m^2$
6	127.0	0.013	0.013	51.4
7	762.0	2.558	2.571	2517.4
8	1778.0	7.223	9.794	7109.5
9	2794.0	7.167	16.960	7053.7
10	3810.0	5.024	21.984	4944.7
11	4826.0	6.347	28.331	6247.2
12	5842.0	5.746	34.078	5655.9
13	6858.0	6.696	40.774	6590.6
14	7874.0	6.984	47.758	6874.2
15	8890.0	7.190	54.948	7076.3
16	9906.0	12.560	67.508	12362.4
17	10922.0	16.762	84.270	16498.3
18	11620.5	0.830	85.100	2177.3

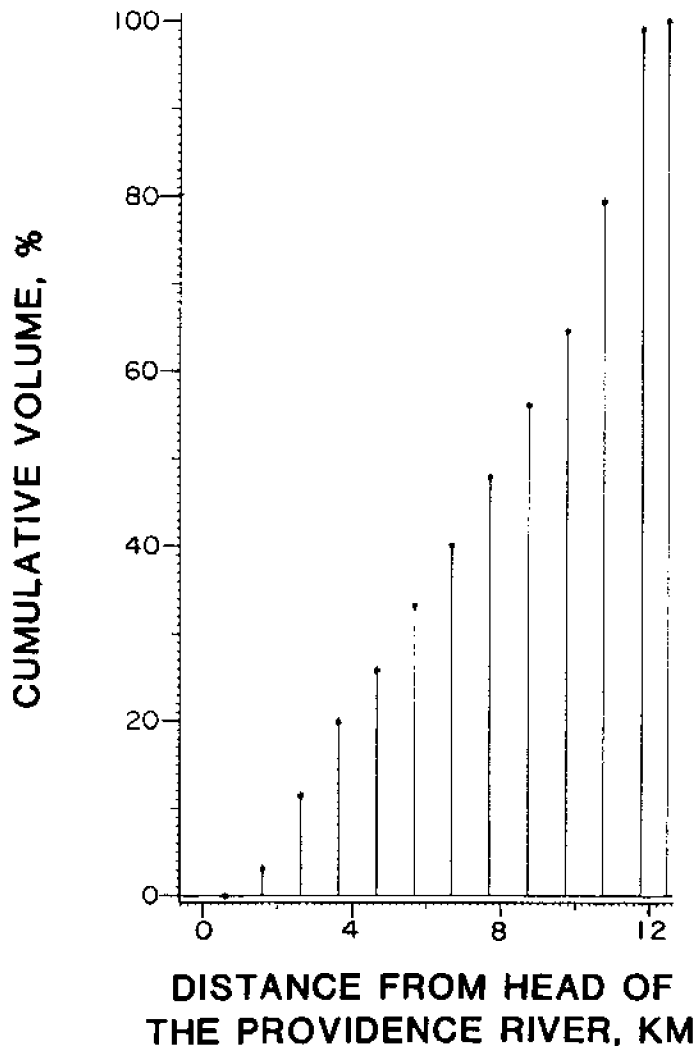


Figure 19c. Cumulative volume of the Providence River below the I-195 highway bridge at Fox Point.



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