A natural laboratory for small estuary studies: the reincarnation of Town Pond

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Abstract

Early maps document a 70 acre salt marsh encased estuary that during the 1950s was filled with dredge spoils by the U.S. Army Corps of Engineers. A number of stakeholders including Save the Bay, a non-profit advocacy group supported a restoration of this ecosystem and in 2006, the Corps of Engineers completed the restoration project. The resulting system offers a unique opportunity to observe the early evolution of a new estuarian ecosystem and provides a natural laboratory for short and long-term studies of the dynamics of small estuaries. This paper briefly overviews the stages leading to the present system, offers a set of experiments that will aid in creating a baseline for future studies and describes progress on a sediment survey currently underway.
Keywords: tidal embayment, estuary dynamics, sediment analysis.

1 The life and rebirth of Town Pond

Town Pond, also known as Boyd's Lane Marsh for the roadway of the same name that abutted the original salt basin, was a 60-80 acre site located at lat lon, 41°38'-7°14', at the northern tip of Aquidneck Island in the town of Portsmouth, Rhode Island USA. The segment of an early map documenting a 1938-39 survey revised ten years later [1] is shown in Figure 1. The map depicts a few important features. First and most obvious is a body of water with an inlet from Mt Hope Bay in the upper area of Narragansett Bay. The map also depicts a vegetative marsh surrounding the embayment and a brook feeding the basin from its south end. A railroad bridge is also seen in this map segment at the upper, marine end, of the basin.

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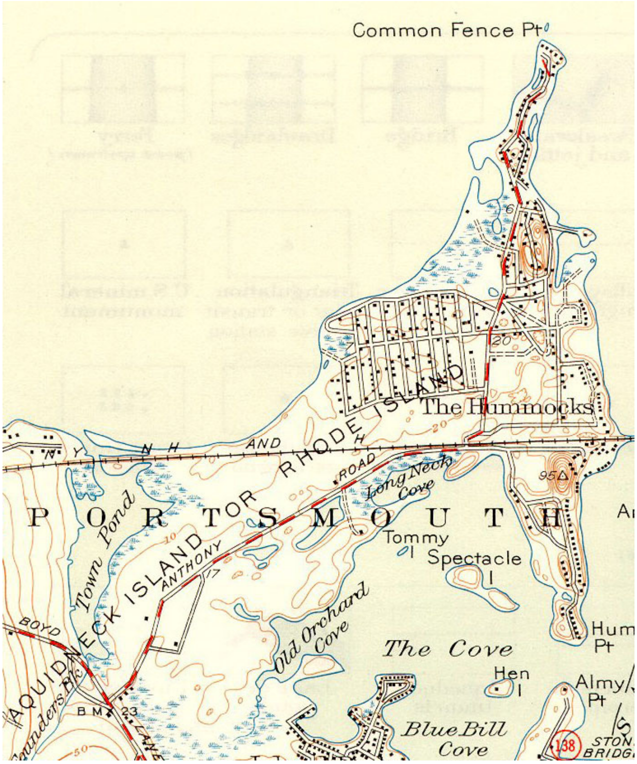

Figure 1: An early map of Town Pond [1].

During the mid 1950s the US Army Corps of Engineers (ACOE) deposited dredge spoils from operations in Mt Hope Bay into Town Pond. This raised the elevation of the estuary gradually resulting in the habitat becoming invaded with *Phragmites* australis and reducing the volume and surface area of salt water accumulation in the system.

Following years of advocacy a partnership, that included the AOCE the RI Department of Environmental Management (RIDEM), the US Environmental Protection Agency, RI Coastal Resources Management Council, Roger Williams University, Aquidneck Land Trust, RI Department of Transportation, Corporate Wetlands Restoration Partnership, Ducks Unlimited, Town of Partmouth and the Narragansett Bay Estuary Program, succeeded in planning and completing a $4.6 million restoration of Town Pond as a functioning estuary. On September 21, 2007 after 50 years of deadly decline, water from Mt Hope Bay flowed into the reincarnated Town Pond.

Figure 2 shows a Google Earth pre-construction view of Town Pond and Figure 3 an overlay of the historic map [1] with a wider view of the Google Earth image.

The spatial extent of the original basin (overlay) is clear on the underlay Google Earth image.

Figure 2: Pre-restoration view of Town Pond from Google Earth.

2 Structure of the new system

Figure 4 shows the re-construction plans for Town Pond including the relevant elevations. According to a June 16, 2008 RIDEM release [3], it was estimated that some 125,000 cubic yards of deposited dredge spoils were excavated creating elevations appropriate for “2.5 acres of high marsh, 8.9 acres of low marsh, 3.2 acres of mudflats and 8.2 acres of permanent open water. A weir with a top elevation of -0.2 feet NGVD will maintain permanent open water depths between 1.8 and 2.9 feet.” The west side of the basin has an earth berm and, coupled with a 42” flap valve, shown in Figure 5, to admit fresh water from Founder’s Brook, this creates a somewhat controlled supply of fresh water to the basin.

Figure 6 offers an aerial view of the site taken on August 16, 2008 about 1 hr 20 minutes after low tide. The photo shows the extent of the renovated basin including the marine and estuary regions as well as the landscape surrounding the renovated site. Founder’s Brook is highlighted to emphasize its location and the earth berm running more or less parallel to the brook can be seen to the east.

Figure 3: Historical map segment overlayed on Google Earth pre-restoration image.

3 A natural laboratory

The aforementioned berm, redirected lower reaches of Founder's Brook and the flap valve, while creating a dynamically different Town Pond than what is seen in the historical maps, nevertheless offers a natural living laboratory for the conduct of investigations of both physical processes as well as fish-, wildlife- and habitat- dynamics. Indeed, the berm limits direct fresh water runoff into Town Pond; in addition to rainfall and pond environs drainage, the major source of fresh water to the basin is from the brook and from runoff that accumulates on the west side of the berm and enters through the valve. Some of the experiments and studies currently underway in our laboratory include:

- An analysis of sediments taken from 28 locations in the marine- fresh- and estuary zones;
- A water balance analysis of the estuary including precipitation, evaporation, fresh water and salt water exchanges from tidal dynamics;
- Transverse and longitudinal salinity gradient studies;
- Analysis of the aforementioned hindsight pre-restoration data;
- Extension of the MSB model [3-6] to estuarian systems and calibration of the model to Town Pond.

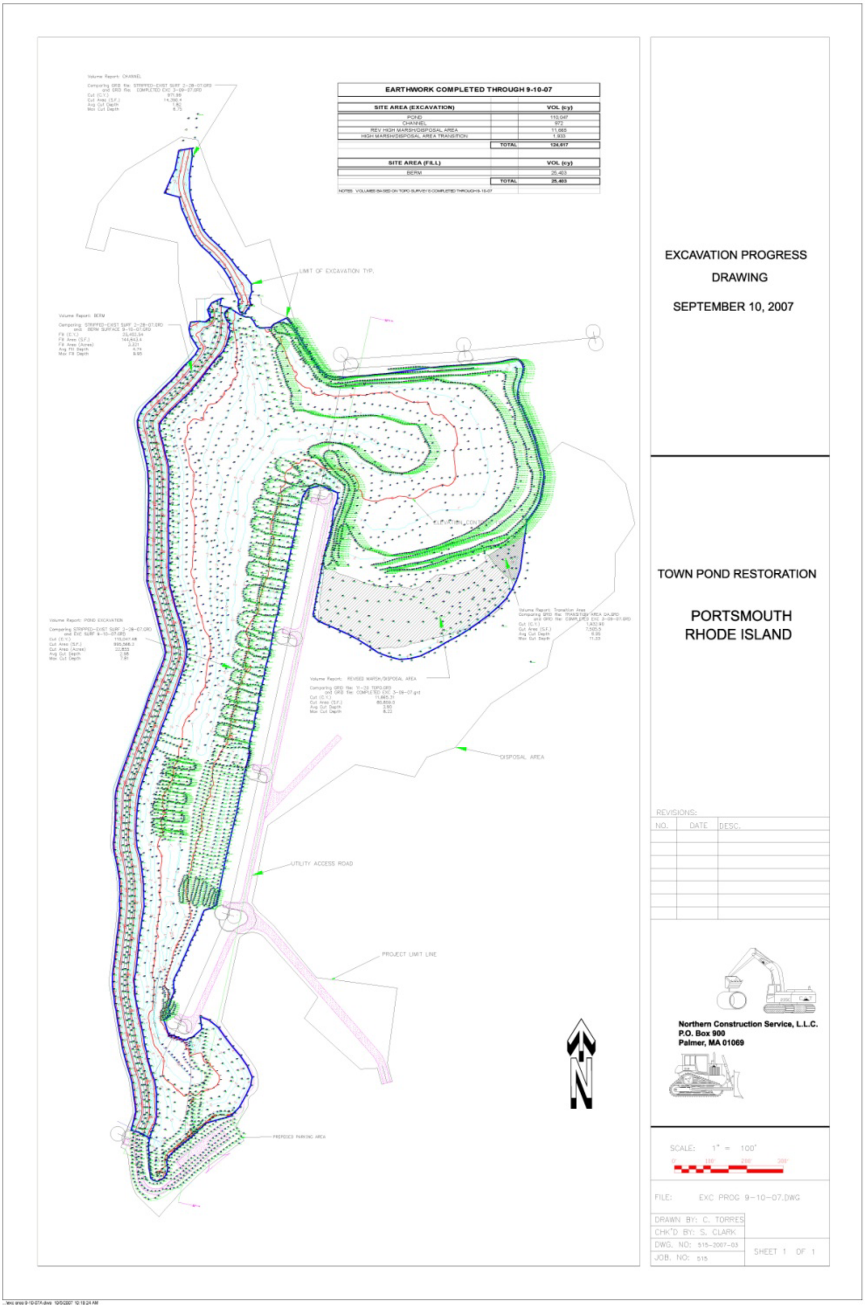

Figure 4: Excavation drawing September 10, 2007. Reprinted with permission.

Figure 5: Photograph of the flap valve and weir.

Figure 6: Aerial view of the renovated site with Founder's Brook highlighted.

It is important that baseline data be established now to give relevance to future observations and studies.

Water height, temperature and salinity data on the pre-restoration system the railroad bridge was acquired over a period of 10 years by a retired engineer (see acknowledgements); and this data. The extent of the tiny basin is not well known and any analysis of this hindsight data will require significant assumptions on spatial and flow parameters, factors that are still being investigated.

4 Sediment preparation and analysis

Sediment samples were taken from 28 points shown in Figure 7. A homemade pneumatic device was used to extract samples from the upper 3-5 cm of the sediment. Simultaneously, surface salinity, depth and time of measurement were also measured as part of a separate survey. Sediments were prepared by drying for 5 hours in a Fisher Isotemp Model 281A oven at a temperature of 85^{o}C. Optimum drying times were determined by observing sample weight as a function of dry time for a typical sample. Dried samples were ground in a mortar and pestle and collected in small vials. Samples weights were set to 250 mg net. INAA (instrumental neutron activation analysis) was used to analyze each sample using the facilities of the Rhode Island Nuclear Science Center. Irradiation times were optimized for adequate counting statistics, sample size and neutron flux. Samples were pneumatically delivered to the core, where the neutron flux was about 4 x 10^{12} n/cm^2/sec, and irradiated for 12 seconds. Actual irradiation flux was monitored using a small Aluminum chad in each sample container. In addition, separate samples of Buffalo River standard sediment was used for concentration calibration purposes. The literature well documents this procedure [7]. This procedure allowed for the analysis of the following short lived isotopes: Al^{28}, Mg^{27}, Ti^{51}, Va^{52}, Na^{24}, CL^{38}, Mn^{56}, K^{42}, Ba^{139}, and Dy^{165}. (Longer lived isotope analysis including several heavy metals are part of another study currently under way.)

Figure 7: Sediment sampling locations.

5 Results and discussion

Table 1 shows the results of sample analysis using the aforementioned INAA technique. Errors in these data, arising from integrated peak count rates, uncertainties in calibration standards and flux monitoring are dominated by the count rates. The ranges of percent errors are summarized in Table 2.

Table 1: Results of INAA on short lived isotopes.

Way Point #	Al 28	Mg 27	Ti 51	Va 52	Na 24	Cl 38	Mn 56	K 42	Ba 139	Dy 165	Salinity	Depth
	%	%	%	PPM	%	%	PPM	%	PPM	PPM	PPT	cm
52	5.38	0.73	0.372	65	1.710	0.529	404	2.43	315	6	28	75
53	6.83	1.15	0.434	83	2.096	0.876	524	3.02	497	8	28	135
54	6.12	0.91	0.392	77	1.936	0.793	443	2.26	337	8	28	112.5
55	6.39	1.01	0.369	81	1.903	0.713	450	2.91	418	8	30	140
56	5.79	1.03	0.322	74	2.055	1.070	446	2.34	297	6	29	135
57	6.18	0.88	0.455	72	1.991	0.728	470	2.71	406	7	29	165
62	4.47	0.87	0.740	84	2.843	2.360	315	1.59	342	4	30	85
63	6.36	0.99	0.407	79	1.963	0.766	410	2.80	416	7	27	30
64	6.18	1.11	0.383	77	1.859	0.729	427	2.67	404	7	27	57
59	7.06	1.13	0.358	76	2.066	0.800	409	2.76	529	9	30.5	80
58	5.43	0.84	0.755	66	1.957	1.060	310	2.24	342	6	30	115
61	5.35	0.89	0.798	65	0.390	0.034	1275	1.42	419	4	23	70
71	3.38	0.00	0.536	31	1.263	0.311	260	1.73	337	3	30	110
72	5.88	1.35	0.364	78	2.066	1.09	470	2.91	441	6	30.5	72
73	2.94	0.00	0.389	33	1.020	0.301	323	1.18	281	2	31	73
74	3.56	0.00	0.572	36	1.220	0.325	359	1.61	356	3	30	74
77	3.76	0.00	0.340	33	1.060	0.0108	902	1.54	339	3	2	77
76	3.46	0.00	0.535	37	0.780	0.00720	538	1.67	348	3	2	76
75	3.52	0.00	0.916	47	0.870	0.00960	1194	1.67	281	3	1.5	75
66	6.71	0.00	0.183	64	0.419	0.0369	1369	1.52	450	5		35
67	1.05	0.00	0.098	10	1.008	0.0155	514	1.82	314	4		30
68	6.17	1.04	0.381	79	1.265	0.0958	444	2.87	408	8	5	30
69	5.46	0.00	0.380	63	1.189	0.0098	489	2.64	480	6	3	20
70	6.39	0.00	0.322	81	0.773	0.0273	783	2.19	459	2	3	30

Table 2: Error ranges for concentration results.

Al 28	Mg 27	Ti 51	V 52	Na 24	Cl 38	Mn 56	K 42	Ba 139	Dy 165
~23%	4%	5%-7%	7%-8%	~5%	15%-29%	4%	11%-14%	36%-38%	9%-17%

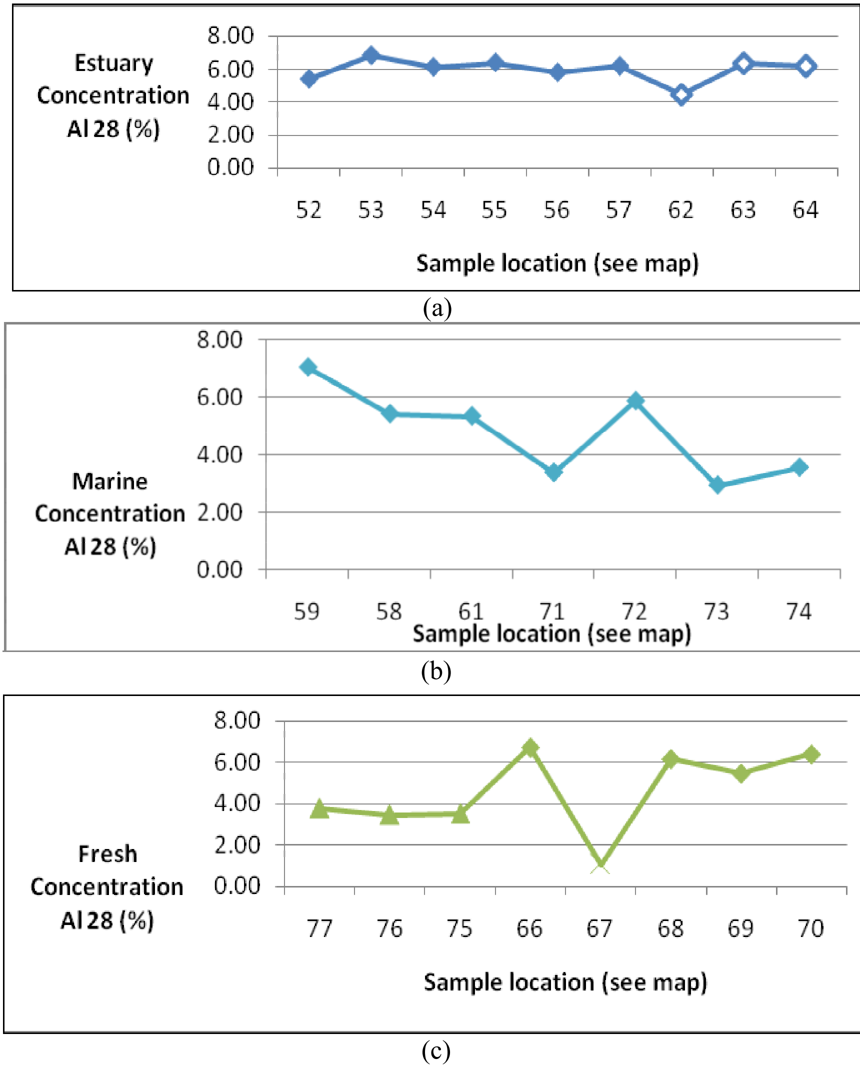

Figure 8: Al-28 Concentration in the (a) Estuary- (b) Marine- and (c) Fresh-Water segments of the Town Pond system.

Samples 52 through 57 are from the west segment of the estuary and 62 through 64 from the west segment. Samples 58, 59, 61, and 71 through 74 are from the marine segment and the balance from the fresh water segment. In order to make sense of much of this data, one must consider the restoration process, which involved the removal of an estimated 125,000 cubic yards of dredge spoils and the replacement with fill soils to create the plan shown in Figure 4. To illustrate the point consider the most abundant isotope in the survey, i.e. Al^{28}. Figures 8(a), (b) and (c) show the measured concentration of Al^{28} at sample locations in the estuary-, marine- and fresh- water segments of the system respectively. Notice in Figure 8(c) the excursions in the Al concentrations. Samples 67 and 68 were taken from just west of the berm and a bit further west respectively in the same general location. The latter was beyond a space that contained dense shrubs, clearly not touched during the restoration and the former in an excavated area. The data supports the hypothesis that sample 68, with an Al^{28} concentration of 6.17 ± 1.4%, was part of the restoration excavation and sample 67, with a concentration of 1.05 ± .24%, was not. Indeed the average concentration in the estuary (Figure 8(a)), which was fully part of the excavation and fill process is 6.0 ± 1.4% similar to the data of samples 66 and 68 through 70, all of which were part of the excavation and re-routing of the fresh water leading to the flap gate. Sample 67 was clearly within the fresh water flow (or overflow) area and 68 showed signs of water draining from the berm or from high water flows from Founder's Brook. Notice that the first three points, 75 through 77, in Figure 8(c) represent samples taken far upstream near the head of Founder's Brook, clearly having a different sediment with average Al^{28} concentration of 3.6 ± 0.8%. While this distinction between segments is noticeable, there are anomalies in isolated samples perhaps due to the mixing of soils including remnant traces of dredge spoils with trucked in fill and longstanding local soils. Multiple samples from each location would help sort out these few excursions in the data.

6 Conclusion

Town Pond offers a unique opportunity to observe the early evolution of a new estuarian ecosystem and provides a natural laboratory for short and long-term studies of the dynamics of small estuaries. This opportunity arises from the newness of the system, the scale and arrangement of the estuary and the rather constrained entry point of fresh water inflow. The present work begins a series of planned experiments that taken together will offer a baseline for modelling the dynamics of the estuary while tracing its actual and potential evolution.

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