Clark Pond, Manchester 2010 - 2011 Report

Submitted to:
Massachusetts DER
Boston, Massachusetts

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February 2012

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EXECUTIVE SUMMARY / ABSTRACT

Clark Pond is a shallow, 12-acre tidally influenced coastal salt pond located on The Trustees of Reservation's Coolidge Reservation in Manchester, Massachusetts. The pond supports a slightly brackish fish community and provides important staging and foraging habitat for number of resident and migratory waterfowl and migratory shorebirds. The pond is fresh water dominated receiving the discharge of two perennial streams that drain a 1.5 square-mile watershed that spans land in Manchester, Magnolia and Gloucester. The pond's 1,200-foot tidal outlet channel flows to Kettle Cove. Salinities rise following spring tide events in the summer when fresh water input to the pond is reduced, but four restrictions along this channel have impeded tidal exchange and fresh water drainage. To improve levels of salinity, lessen flooding and reduce the non-native common reed (*Phragmites australis*), The Trustees of Reservations and private landowners began a system-wide restoration that included the expansion of four restricting crossings and the widening of a stone sluiceway. Pre-restoration vegetation, nekton and salinity monitoring was conducted in 2010 by Salem Sound Coastwatch for the Division of Ecological Restoration and again in 2011 after the restrictions were removed.

Two goals of the Clark Pond tidal flow restoration are to increase the functioning of a salt and brackish marsh community with additional native halophytes including cordgrass (*Spartina spp.*) and to reduce the coverage of invasive species. A mix of fresh, brackish, and saltwater tolerant plant species grow in the wetland border. *Spartina pectinata* is the most abundant native halophyte in this marsh community. *Phragmites australis* is the most dominant invasive plant. *Phragmites* coverage decreased in both transects from 2010 to 2011, but continued monitoring is necessary to determine if this decline is related to the removal of the tidal restrictions or yearly variations. Water and pore salinity measurements show that seasonal variations continue to be the prime driver of salinity in Clark Pond and its border. The current similarity in nekton species richness and abundance between the two years suggest that additional sampling methods are probably necessary for a more effective evaluation. The restoration had just been completed when post-restoration monitoring took place. There is a strong likelihood that biodiversity and salinity will improve over time with the increased tidal flow and as the fresh water leaves the system more quickly through the larger outlet channel. Therefore, future monitoring across the pond and wetland border will be important to assess change.

INTRODUCTION

1. Site Background Information

The following description is excerpted from The Trustees of Reservations grant proposal to the Gulf of Maine Council on the Marine Environment: Habitat Restoration dated 4/2/2010:

> Prior to the 19th Century, Clark Pond and the lowland between Grey Beach and Kettle Cove was salt marsh with tidal connections to both the east (Grey Beach) and west (Kettle Cove). Clark Pond was created approximately a century ago when the old inlet from Grey Beach was filled and a dike was constructed across the marsh, creating the impoundment. To provide an outlet for the pond, a tidal channel west of the impoundment was expanded and connected to Kettle Cove.
>
> Today, Clark Pond is a shallow, 12-acre tidally influenced coastal salt pond located on The Trustees of Reservation's Coolidge Reservation in Manchester, Massachusetts. Overall the pond supports a slightly brackish fish community. In addition, the pond supports habitat for the catadromous American eel and estuarine species such as killifish, mummichogs, sheepshead minnow, and blue crab, which breed in the system. This system provides an important feeding ground for several species of forage fish that directly support a growing recreational fishery found along the eelgrass beds in Kettle Cove and the surrounding Salem Sound.
>
> In addition, the Clark Pond system provides important staging and foraging habitat for number of resident and migratory waterfowl and migratory shorebirds. Resident waterfowl such as mallards and black ducks reproduce in the system, and blue and little blue herons, snowy and great egrets, green herons, black-crowned night herons, and migratory shorebirds such as spotted sandpipers routinely feed in the pond's shallow waters. Winter waterfowl include bufflehead, common goldeneye, and mergansers. The pond is also a critical foraging area for the largest colonial waterbird rookery in Essex County—found on Kettle Island and located less that one-half-mile offshore from Clark Pond.
>
> Clark Pond receives the discharge of two perennial streams that drain a 1.5 square-mile watershed that spans land in Manchester, Magnolia and Gloucester, Massachusetts. The pond is freshwater dominated. However, salinities rise following spring tide events in summer when freshwater flow into the pond is reduced. The pond's surface water elevation is roughly equivalent to the height of mean high tide: 4.99 NGDV (9.12 tidal datum), and the pond regularly receives tidal influence and salt water inflow. Together with the pond's drainage, a 1,200-foot-long, tidally influenced stream comprised of two small ponds and stone sluiceway, this 15-acre area supports a mix of fresh, brackish, and salt water tolerant plant species.
>
> However, four restrictions along Clark Pond's 1,200-foot drainage impeded tidal exchange and fresh water drainage. Reduced tidal influence effects salinity, water quality—especially during low flow periods during the summer, and community composition and the encroachment by non-native common reed (*Phragmites australis*). In addition, the watercourse is overwhelmed during large rain events when freshwater inflow from the

surrounding watershed exceeds the system's drainage capacity, leading to the occasional flooding of adjacent trails and Coolidge Point Road.

Current ownership of the project area:
The majority of Clark Pond is owned, preserved, and protected in perpetuity by The Trustees of Reservations (TTOR). Dr. Dorothy Ganick, who is supportive of the restoration effort, owns a small portion of the pond's northeast corner

Figure 1. Location of Clark Pond between Kettle Cove (left) and Grey Beach (right)

Actions Taken
TTOR, in collaboration with a private landowner – the Lastavicas, have worked together to design a system-wide restoration that includes the expansion of four restricting crossings and widening of a stone sluiceway. The following actions were completed by September 2010:

1. In-depth hydrological assessment of Clark Pond (Horsley Witten Group, 2006)
2. Detailed topographic and wetland delineation of the system (Beals and Thomas, Inc., 2006)
3. Widening of the stone sluiceway by 30% and removing what had been the most restrictive section (Lastavicas 2007-2008)
4. Priority Wetland for Restoration designation by Massachusetts Division of Ecological Restoration (DER, formerly the Wetlands Restoration Program) (2008)

Phase Two, removal of all four restrictions downstream and the replacement of the undersized granite culvert and granite slab footbridge with an open, stone and masonry channel, Phase Three, were completed by May 2011. A wooden footbridge was constructed across the channel to maintain public access to the property. The dimensions of the new channel is 8 feet wide, 2.5 feet wider than the prvious 5.5-foot wide channel, and the lower and upper inverts were adjusted

slightly to improve flow characteristics. A doubling of the channel's flow capacity from 70 CFS to 150 CFS is expected. Replacement of the granite slab footbridge with a wooden structure day-lighted seven linear-feet of stream length, as the footbridge width was reduced from its present 17-foot width to 10 feet.

Permitting for the project was contracted with Beals & Thomas, Inc. Permits Required:

1) Local Order of Conditions from the Manchester Conservation Commission
2) Chapter 91 Waterways License
3) Army Corps of Engineers Section 404 Programmatic General Permit

Pre-Construction

Figure 2. - Pre-construction: culvert and footbridge tidal restriction at Clark Pond

2. Goals / Objectives

As defined by TTOR, the primary goals of this project are the following:

1) Improve the tidal connection between Clark Pond and Kettle Cove, thereby restoring a 12-acre coastal wetland system to a coastal salt pond and salt marsh that supports wildlife habitat, fisheries, nutrient production and export, and biodiversity
2) Protect public property and safety by reducing the frequency and severity of freshwater flood events.

The project will achieve the following objectives:

- Improve tidal connectivity between Clark Pond and Kettle Cove.
- Restore a functioning salt and brackish marsh community dominated by native halophytes including cordgrass (*Spartina spp.*) through restoration of tidal flow.
- Provide coastal resiliency by creating additional storm water buffering capabilities through increased drainage capacity.

- Improve public safety by replacing a dilapidated crossing with an ADA compliant structure.

Pre-construction vegetation, nekton and salinity monitoring was conducted from 7/2/2010 through 9/21/2010.

Post-construction

Figure 3. New footbridge replaced in 2011 at Clark Pond

The new footbridge was replaced before post-construction monitoring was conducted from 6/08/2011 through 8/11/2011.

METHODS

1. Study Site

Clark Pond is a shallow, 12-acre tidal influenced coastal salt pond located on The Trustees of Reservation's Coolidge Reservation in Manchester, Massachusetts. The pond's outlet, a tidal channel west of the pond, connects to Kettle Cove and is also part of this study since the undersized granite culvert and granite slab footbridge restriction was replaced to double the channel's flow capacity from 70 CFS to 150 CFS.

2. Restoration Monitoring Methods by parameter

WATER CHEMISTRY – SALINITY

Sampling Procedures

The water chemistry effort measured ground water salinity at five stations around the edge of Clark Pond as well as water from the pond and creek channel. Sippers were used to collect pore water at Stations 3 through 7 (see Figure 3). A VISTA Series Instruments Portable Refractometer (model number A366ATC (0-10% Sal.) was used to measure salinity when sippers were used. The sensor on the refractometer was rinsed with deionized water and dried between readings. The error of the refractometer used to measure salinity, could be as much as 1.0 ppt. Surface water salinities were measured from the creek channel (Station 1) and the pond (Station 2) using a YSI 30 in 2010 which measures salinity, conductivity and temperature. In 2011 all measurements were taken with a refractometer.

All salinity measurements were recorded onto the Salinity Field Data Sheet. Data sheets included names of volunteers, site name, date, time of sampling. Salinity measurements were collected July 2, July 29, August 24 and September 21, 2010 and again on June 8, July 7 and August 11, 2011.

Figure 4.
SSCW staff measure pond salinity with a YSI (left) and pore salinity with a sipper and refractometer (right).

STATION 1: Channel water. Salinity data collected during nekton survey
STATION 2: Pond side of culvert
STATION 3: Fringe marsh south of culvert. Sipper and pond
STATION 4: Marsh by Grey Beach. Sipper
STATION 5: Fringe marsh off path north of culvert. Sipper
STATION 6: Across from 8 Raymond Rd. Enter at clearing from street. Sipper sample taken at edge of pond
STATION 7: 16 Raymond Rd. Enter at clearing from street. Sipper sample taken near edge of pond

Figure 5. Locations of salinity measurements at Clark Pond in summer of 2010 and 2011

VEGETATION

Since the wetland edge of Clark Pond is, in general, a narrow fringing marsh, Transect 1 was established parallel to the pond edge one meter in from the water. There are larger wetland areas on the northern section of the pond edge, but these are dominated by *Phragmites australis* and difficult to access because of the dense growth. Transect 2 measured the Phragmites along the northern side of the creek channel downstream of the restriction created by the granite culvert and granite slab footbridge.

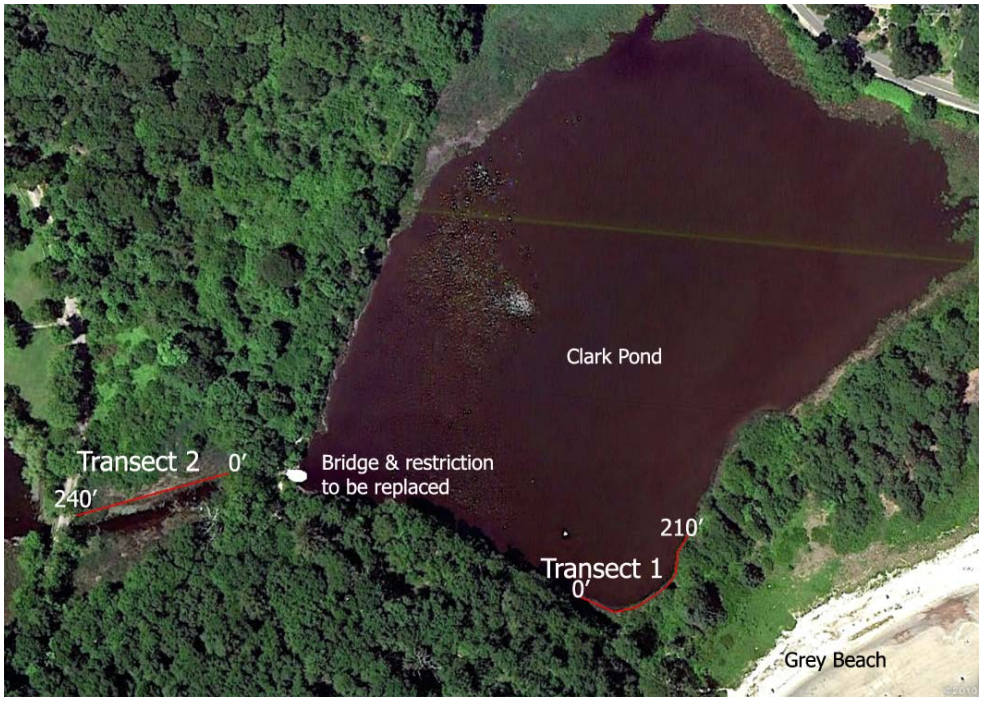

Figure 6. Locations of vegetation transects at Clark Pond in summer of 2010 and 2011.

Sampling Procedures

Vegetation monitoring followed monitoring protocols outlined in Carlisle, B.K. et al., 2002. A Volunteer's Handbook for Monitoring New England Salt Marshes. Massachusetts Office of Coastal Zone Management, Boston, MA. An online version of this handbook can be obtained from www.mass.gov/czm/volunteermarshmonitoring.htm.

Vegetation monitoring methods used a meter^2 plot frame constructed from ½ inch PVC material, which was placed every 30 feet along each transect. Vegetation Transect 1 ran 140^o for plots at 0, 30 and 60 feet; then 70 ^{o} for the remainder of the plots. Vegetation Transect 2 ran parallel with the creek channel on the north side from 0 feet to 240 feet (the driveway is at 250 feet). Vegetation monitoring within each plot consisted of species presence / absence, percent cover, and height of 10 tallest *Phragmites australis* stems where applicable. Vegetation sampling took place in September in 2010 and August in 2011. All plants were surveyed on the same day. Transects were run one meter in from water's edge; then plot frame was placed between the

measuring tape and water. Plot frames were positioned so that the bottom left-hand corner of the frame was always located at the designated distance on the tape (e.g., at 120 feet).

Starting at the first plot on the first transect, every plant that fell within the $1m^2$ plot frame was identified. The scientific name (genus and species) of each species was recorded on the field data sheet, Plant Survey Field Data Sheet. Using the Salt Marsh Vegetation Survey: Standard Cover Classes and Midpoints for Estimating Abundance worksheet, the cover class was selected that most accurately portrayed the abundance of each species in the plot. All leaves, branches, and stems that fell within the vertical column made by the plot frame extended upwards were included. Total abundance for all species in the plot may total more than 100%, as plants may have overlapped each other. Plot coverage estimates, which included areas within the plot frame that were not occupied by living vascular plants, were called "Other." This category included wrack, debris, dead leaves, bare ground, and open water.

In the plots where *Phragmites* occurred, the height of the tallest 10 living individuals was measured (in plots containing less than 10 plants, all living plants were measured). Plants were measured from the ground to the very tip of the inflorescence (flowering part of the plant); or if no inflorescence was present, plants were measured to the tip of the highest leaf.

All data were recorded on the field data sheet. Names of investigators, site name, date, reference or study, transect number, distance from origin point, compass bearing of transect; plot ID, location on transect (feet), genus, species, % cover. If there was trouble identifying a specimen using A Field Guide to Coastal Wetland Plants of the Northeastern United States (Tiner 1987), Field Guide to Coastal Wetland Plants of the Southeastern United States (Tiner 1993) or a different field guide, the specimen was called "Unknown Species A" in the field data sheet and the plant and part of its roots were placed into a resealable plastic bag (along with a label) for later identification.

Figure 7. Vegetation Transect 1 at Clark Pond, summer of 2010 and 2011

Figure 8. Vegetation Transect 2 at Clark Pond outlet creek channel, summer of 2010 and 2011. Transect begins at the edge of the *Phragmites australis* and runs 240 feet westerly to the driveway.

NEKTONS

The creek was seined for nektons on July 2, July 29, and August 24, 2010 and again in 2011 on June 8, July 7 and August 11. On the first sampling date, July 2, 2010, the pond was also seined in the area of vegetation transect 1, but samplers found it a very difficult undertaking since the pond substrate is very mucky. It was determined that this would not be sampled in the future because of the danger of someone getting stuck or tripping on the debris hidden under the water. Catch stability is low with seines, but seines can capture a variety of fish and crab species in a sample area.

Figure 9. SSCW staff and summer interns prepare to seine the creek channel for nektons

Sampling Procedures

A seine was borrowed from Mass Audubon's Wenham office the first year and then DER funds were used to purchase the seining net seen in Figure 9. Seining on three sampling dates per summer collected nektons. The samplers walked down the path through the *Phragmites* approximately 100 feet. The net was stretched across the stream and pulled upstream into the current. Samplers worked to keep the weighted net bottom on the stream substrate, but conditions were not ideal since the substrate was mucky and littered with sticks, branches and rocks. The net was pulled out just upstream of the channel tide gauge staff shown in Figure 10.

Figure 10. Tide gauge and exit location of seine

On June 17, 2011, seining was conducted on an incoming high tide (i.e., moving downstream into the current away from the footbridge, but no fish were caught and sampling was repeated later on an outgoing tide. Thus, all results are from an outgoing tide.

Steps outlined in A Volunteer's Handbook for Monitoring New England Salt Marshes were followed. Nektons were identified to species and counted. If more than 40 individuals of any particular species were collected, a sub-sample of 40 individuals was randomly sampled. A small net was used to capture fish from the bucket containing the entire individual species catch. The length of the first 40 of each species was measured to the nearest millimeter and then the 40 were weighed to the nearest gram to determine the aggregate weight. Any external abnormalities, such as skin lesions or parasites were noted. The remaining fishes of a species were counted and weighed. All were returned to the water as soon as possible to avoid mortality.

Figure 11. Measuring length of the first 40 fish of a species

Templates of each datasheet can be found in Carlisle *et al*. (2002). All data were recorded on the field data sheet, entered into MarshDB and then analyzed in MS Excel.

Results and Discussion

Physical

Pore water salinity was lower than the salinity of the pond or outlet channel for both years of monitoring. The replacement of the footbridge, which enlarged the Clark Pond outlet, did not result in an immediate rise in salinity. In fact, salinity readings in both the pore water and the pond and channel were lower in the post-restoration year.

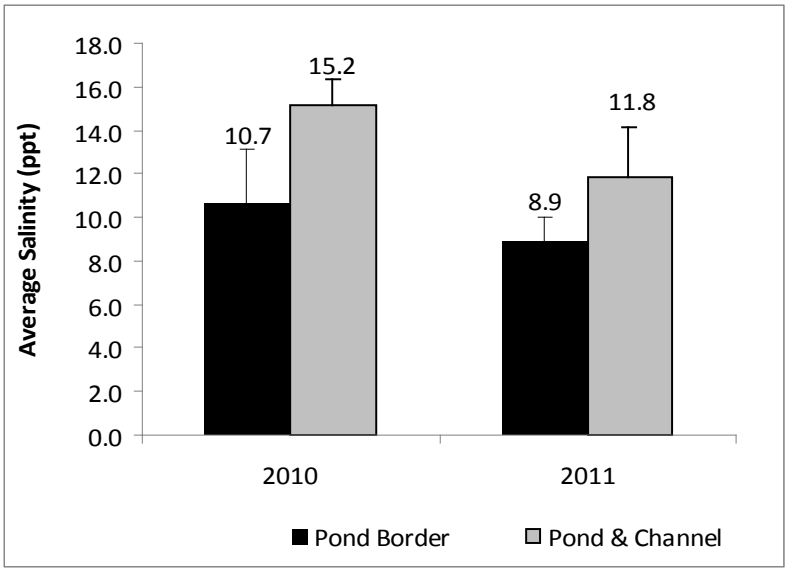

Figure 12 - Annual pore water salinity averaged across depths for 2010 pre-restoration and 2011 post restoration compared to salinity readings averaged from the pond and outflow channel at the footbridge. Bars represent means ± SE.

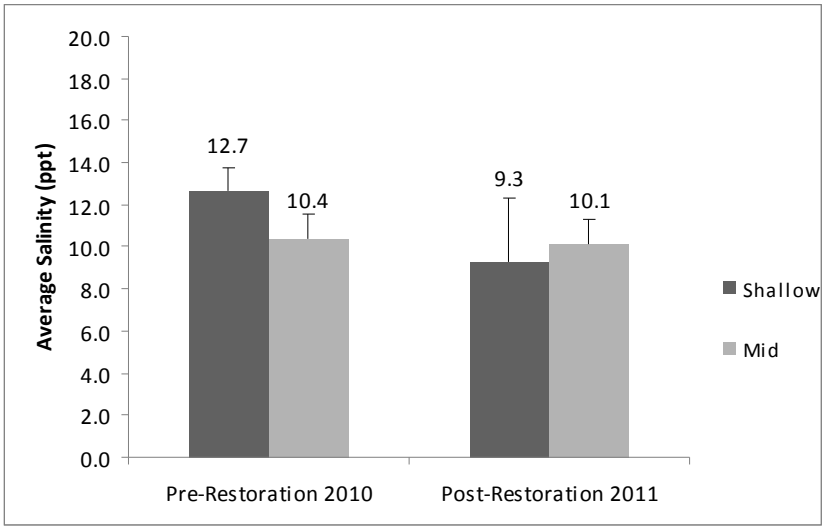

Figure 13 – Pore water salinity across Clark Pond wetland border (pre restoration and post restoration) and depth (shallow and mid). Bars represent means ± SE.

Pore water salinity was further analyzed across depth for the one year of pre restoration and one year of post-restoration data. No trend was discernible between depth and pre restoration vs. post restoration. Readings for August 2011 were not used (Table 1 *) because of quality control issues. Salinity readings were 0 ppt, which were initially believed to be the result of 2-4 inches of rainfall, but when the refractometer was retested back at the office, it was found to be defective.

Table 1 – Monthly pore water salinity averaged across depths for 2010 pre restoration and 2011 post restoration compared to salinity readings averaged from the pond and outflow channel.

		June	July	August	Sept
2010	Pre-Restoration Pond & Channel		15.6	15.2	11.3
2011	Post-Restoration Pond & Channel	14.3	6.9	*	
2010	Pre-Restoration Pore Salinity		9.8	13.1	8.8
2011	Post-Restoration Pore Salinity	8.8	9.0	*	

Pore water salinity generally demonstrates a seasonal variability with the lowest salinities occurring in the spring and highest in the late summer (Table 1). If both years are viewed as one, this trend is evident with August having the highest pore salinity.

In August 2010, the highest single pore salinity reading (20.5 ppt) of all data recorded over the two years was collected at sipper location 6. August 2010 was extremely hot and dry. Similar high salinity pore water readings were also observed at Mill River marsh in Gloucester, which had readings of 30 ppt and 35 ppt (Transect 1- 10 m & 35 m), while the channel water was 26 ppt. All the rest of Mill River marsh sipper locations were dry except for these two in the marsh peninsula. If this 2010 August outlier at Clark Pond is removed, the average salinity at sipper 6** is 11.8 ppt, rather than 14 ppt (Table 2).

Table 2 – Averaged pore water salinity at each sipper sampling location around Clark Pond for 2010 pre restoration, 2011 post restoration and the combined two years. ** When outlier removed from sipper 6.

Sippers	3	4	5	6	7
2010	10.3	6.2	12.8	14/11.8**	7.3
2011		5.1	8.9	6.0	7.1
Averaged	10.3	3.9	11.5	13.1/11.8**	9.1

Pore salinity was collected from five stations around the 12-acre pond. Future monitoring and analysis should concentrate on comparing different sections of the pond. Because of their distance from tidal flow from Kettle Cove and their proximity to fresh water runoff from the upstream watershed, sipper stations 6 and 7 off of Raymond Road would probably continue to have lower salinity readings.

The replacement of the undersized granite culvert and granite slab footbridge restriction that doubled the channel's flow capacity from 70 CFS to 150 CFS did not result in salinity changes in and around the pond, during the few months after its replacement. This short post restoration time and the fact that Clark Pond receives water from Kettle Cove via a 1,200-foot tidal channel may be explanations for this lack of change (See Figure 1 (pg 7).

Vegetation

Clark Pond is fresh water dominated but does have a mix of fresh, brackish and saltwater tolerant plant species. Species richness increased by 3 species from 2010 to 2011 from 8 species to 13. *Spartina pectinata* and *Agrostis* species were the most abundant. *S. pectinata* is a fresh water cordgrass that is often found on upland edges of salt marshes where the soil is drier. *Scirpus validus*, a soft-stemmed bulrush that frequents brackish to tidal fresh water marshes, dominated the first half of the pond transect before the *Phragmites australis* took over. *Galium tinctorium* (dye bedstraw), *Vitis aestivalis* (wild grape climbing woody deciduous vine) and *Calystegia sepium* (bindweed vine) were found in the undergrowth. These plants can be found in a wide range of habitats including irregularly flooded tidal fresh marshes.

Table 3 – Individual plant species cover averaged for the study pond edge for both years monitored.

Individual Plant Species Cover	Percent Coverage	
Species	2010	2011
Agrostis sp	19	50
Aster tenuifolius	4	0
Atriplex sp.	0	2
Calystegia sepium	5	16
Galium tinctorium	0	25
Lythrum salicaria	0	11
Phragmites australis	31	9
Polygonum punctatum	3	2
Scirpus validus	18	20
Smilax rotundifolia	0	3
Spartina pectinata	39	46
Typha latifolia	5	9
Vitis aestivalis	0	25
Unknown plant	0	15
Other -bare, wrack, water	26	28

Table 4 – Plant species cover in 2010 and 2011averaged for the north side of the creek outlet to Clark Pond.

Individual Plant Species Cover	Percent Coverage	
Species	2010	2011
Phragmites australis	59	28
Agrostis sp.	1	39
Calystegia sepium	13	8
Atriplex sp	1	3
Solidago sempirvirens	0	3
Polygonum punctatum	1	0
Other: bare, water, wrack	40	62

The vegetation transect sampled along the north side of the tidal channel between the footbridge and the driveway was dominated by *Phragmites* as evidenced by the 59% coverage in 2010. The increase in "Other" in 2011 and the decrease in percent coverage of *Phragmites* may be indicative of a trend that is worth further study. There was a definite increase in bare ground, standing water and dead cover consisting primarily of *Phragmites* stalks in August 2011.

Species richness of halophytes is very low at Clark Pond because of the low salinity of the pond due to fresh water from two northerly inlets and watershed drainage. Only four plant species were halophytic. *Aster tenuifolius, Atriplex* sp. and *Solidago sempirvirens* were present in very low numbers. However, *Spartina pectinata* or prairie cordgrass was quite common along the pond edge transect. *S. pectinata* is often found at the upper reaches of a salt or brackish marsh and provides excellent habitat for waterfowl and animals, such as muskrats. The more saltwater dependent Spartina species, *Spartina alterniflora* and *Sp. patens* were not present in 2010 or 2011 in the wetland bordering the pond or the channel. *Juncus gerardii* was seen on along the north side of the tidal creek between the footbridge and the *Phragmites* dominated area (before the start of transect 2).

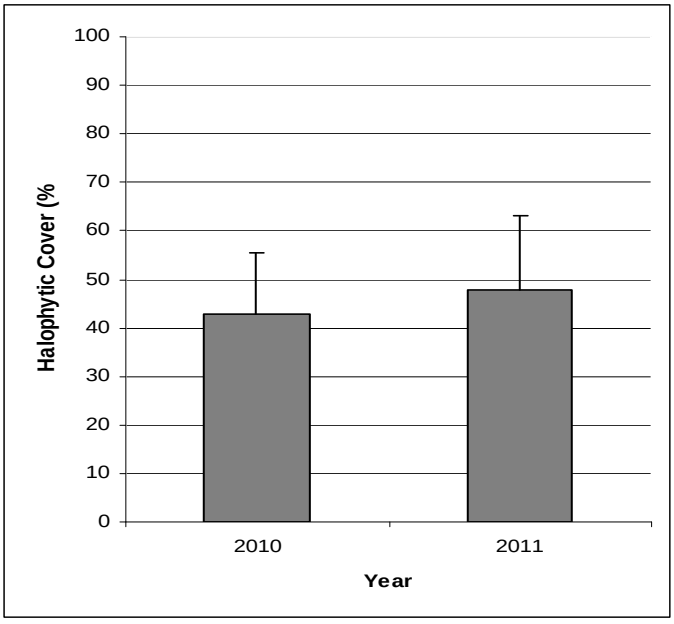

Figure 14 – Annual species richness of halophytic plants grouped by year Bars represent means ± SE (n = 12).

Table 5 – Halophytic percent cover in 2010 and 2011 from combined Clark Pond and north side of pond outlet.

Halophytic cover	2010	2011
Aster tenuifolius	4	0
Atriplex sp.	0	2
Solidago sempirvirens	0	3
Spartina pectinata	39	46
Average	43	51

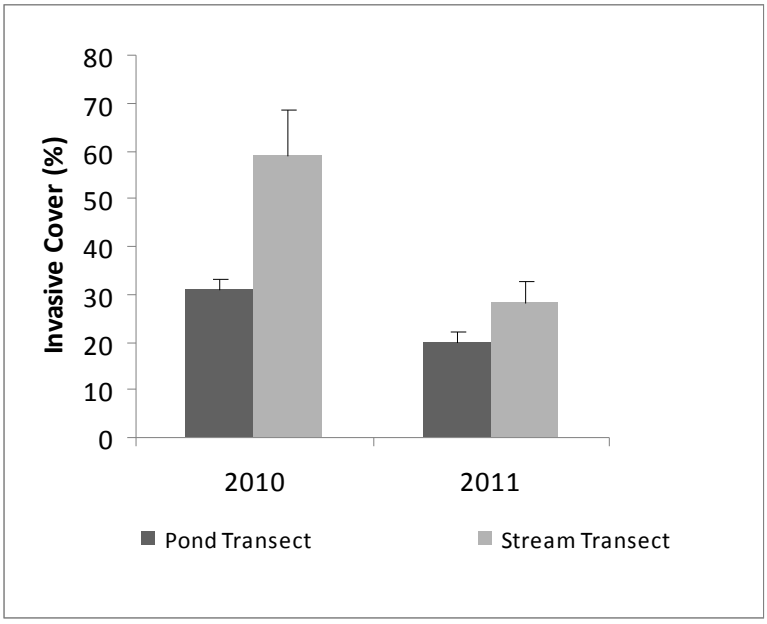

Figure 15 – Annual invasive plant cover (%) grouped by transects for each year.

The only invasive plant found in the two transects in 2010 was *Phragmites australis*. In 2011, *Lythrum salicaria* (purple loosestrife) was also found either as single plants or small groupings along the pond edge, but nowhere did it dominant or cover extensive areas. In contrast, where *Phragmites* was present, it dominated. The abundance of *Phragmites* in both transects decreased from 2010 to 2011, but more monitoring will be needed before any conclusion can be drawn about its possible decline (Table 4). *Phragmites* height was slightly higher in 2011 at both transects.

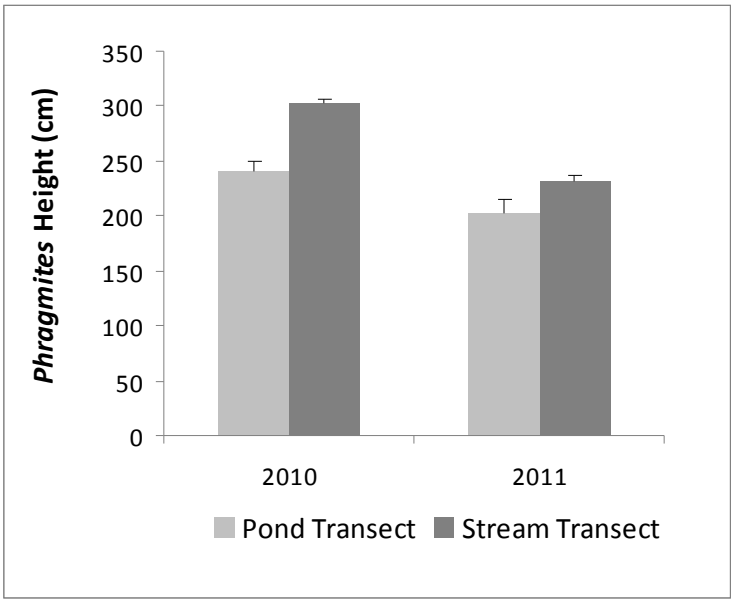

Figure 16 – Annual *Phragmites australis* plant height (cm) grouped by transects for each year.

Nekton

Three fish species (*Fundulus heteroclitus, Menidia menidia, Gasterosteus aculeatus*) and one crustacean species (*Palaemonidae - Paleomenetes pugio or vulgaris*) were captured. The most dominant species in terms of abundance was *F. heteroclitus,* comprising 80 % of the nekton captured in the seine. Only the tidal channel that flows between Kettle Cove and Clark Pond was sampled. Initially, the intention was to also sample from the pond near the vegetation transect, and this was attempted once on 7/02/2011. Because the pond's thick mucky substrate presented safety risks to researchers, it was not attempted again. *Fundulus heteroclitus* and *Menidia menidia* were found from the one pond seining.

The species richness of nekton was the same for both years, with the exception of the one grass shrimp collected in 2010 (Table 3).

Table 6 – Individual nekton species count and abundance averaged for each year monitored.

Species	2010 Pre-Restoration Count	2011 Post-Restoration Count	2010 Pre-Restoration Abundance	2011 Post-Restoration Abundance
Atlantic Silverside	155	47	52	47
Threespine Stickleback	4	1	4	1
Mummichog	315	539	105	270
Grass Shrimp	1	0	1	0

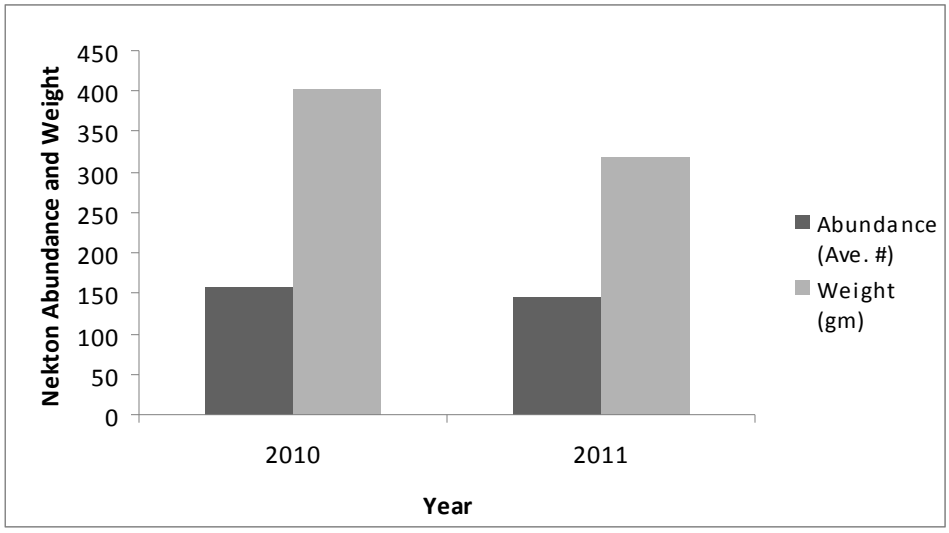

Figure 17 – Annual species abundance of nekton grouped by year.

Neither average species abundance nor average weight varied between the two years of sampling. Fish biomass was reported in two different groups, resident and transient species. Overall, resident fish species – the mummichogs (*Fundulus heteroclitus*) made up a greater proportion of caught fish biomass than transient fish species – Atlantic silversides and threespine sticklebacks (*Menidia menidia*, *Gasterosteus aculeatus).*

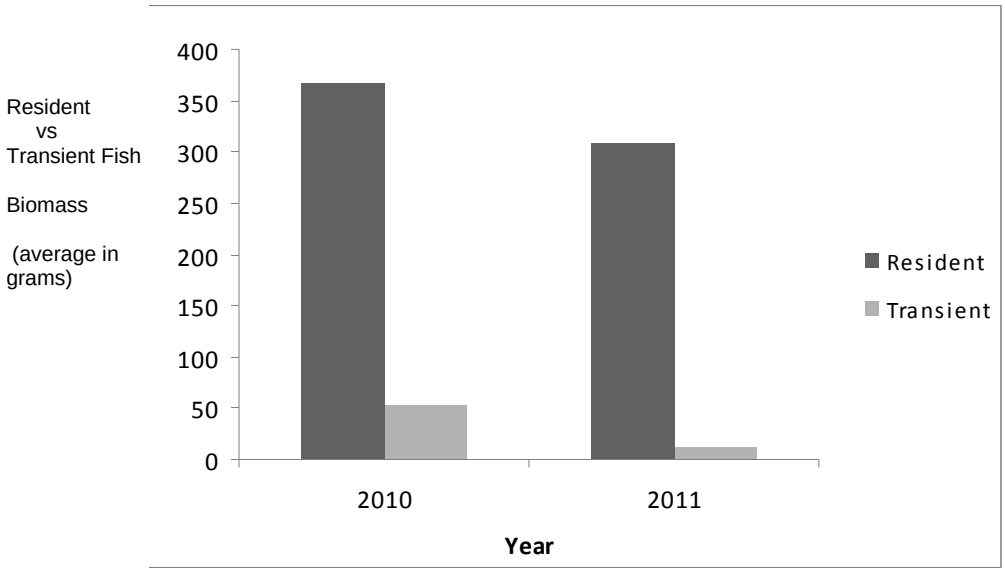

Figure 18 – Annual fish biomass of resident species and transient species grouped by year sampled.

There were no differences in nekton species composition, richness or abundance in the two years. Sampling techniques may have limited the collection of species since only the outlet was seined, and seining had to take place on an outgoing tide. In 2011, seining on an incoming tide was conducted, but no fish were captured. The outlet while manageable was still difficult to seine because of the mucky substrate, debris and rocks in the channel. It may be possible that American eel is present in the pond, but none where collected. In the past, Salem Sound Coastwatch has collected eels in minnow traps as well as crabs and shrimp plus the species of fishes collected with the seine. Future nekton monitoring could include minnow traps in the pond and repeated seining in the tidal channel outlet.

Summary

Removal of tidal restrictions at Clark Pond was just completed when Salem Sound Coastwatch conducted post restoration monitoring in 2011. Results of these restoration efforts will not be immediately evident as shown by the lack of significant differences when data from the one year of pre and one year of post restoration monitoring were compared. Ecological improvements from marsh restoration take time. Analysis of 36 salt marsh restoration projects by Konisky et al. (2006) found that it can take three or more years after restoration before plant communities shift toward increased cover of halophytes and lower cover of brackish species. The monitoring conducted at Clark Pond does provide a baseline for future assessments.

Presently, seasonal variations appear to be the prime driver of salinity in Clark Pond and its wetland edges. Pore water salinity should continue to be observed at stations around the 12-acre pond to determine if any section of the pond is receiving more tidal influence. It is most likely that stations off of Raymond Road will continue to have lower salinity readings than areas near the tidal channel.

Two of the Clark Pond tidal flow restoration goals were to increase the functioning of a salt and brackish marsh community dominated by native halophytes including cordgrass (*Spartina spp.*) and to reduce the coverage of invasive species. *Spartina pectinata* is a native halophyte that is prevalent along the pond wetland edge. Monitoring established a baseline for the diversity of plant species ranging from fresh to brackish tolerant. *Phragmites* coverage decreased in both transects from pre to post restoration, but continued monitoring is necessary to determine if this decline is related to the removal of the tidal restrictions or yearly variations.

The pond is reported to support habitat for the catadromous American eel and estuarine species such as killifish, mummichogs, sheepshead minnow, and blue crab. The nekton sampling with a seine did not find minnows, blue crabs or American eel, but that does not mean they do not or could not exist in this habitat. The current similarity in nekton species richness and abundance suggest that additional sampling methods are probably necessary for a more effective evaluation. The restoration efforts just completed will strengthen the likelihood that biodiversity will increase as tidal flow expands and fresh water leaves the system more quickly through the larger outlet channel. Monitoring vegetation, salinity and nektons at different areas of the pond and its wetland border should be conducted every three to five years to assess changes in the Clark Pond ecosystem.

ACKNOWLEDGEMENTS

The Massachusetts Division of Ecological Restoration, Department of Fish and Game funded this effort.

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DATA APPENDIX

i. Data table of physical parameters (pore water salinity).

ii. Data table of vegetation parameters (species composition and associated cover, species richness of halophytes, halophytic and invasive species cover, and the average height of *Phragmites australis*).

iii. Data table of nekton parameters (species composition and associated density, nekton species richness, total fish density, fish biomass of resident and transient species)