

2011 Freshwater Mussel Survey in Mystic Lake (Barnstable, Massachusetts)

Report Prepared by: Biodrawversity LLC
433 West Street
Amherst, MA 01002
Ethan Nedeau, principal



Report Prepared for: Town of Barnstable
367 Main Street
Hyannis, MA 02601

INTRODUCTION

Between 2007 and 2011, Biodrawversity LLC conducted three lake-wide surveys for freshwater mussels in Mystic Lake in Barnstable, Massachusetts. The first survey, completed for Mr. William Sauerbrey in 2007, determined the distribution, density, and habitat of three state-listed species: tidewater mucket (*Leptodea ochracea*), eastern pondmussel (*Ligumia nasuta*), and triangle floater (*Alasmidonta undulata*) (Biodrawversity 2007). During the two-day survey, researchers counted a total of 529 tidewater muckets, 10 triangle floaters, and 9 eastern pondmussels. Together with similar surveys conducted in other coastal ponds from 2007-2009 (Biodrawversity 2008, 2009, 2010a), results from this survey suggested that Mystic Lake supported one of the three best known tidewater mucket populations in Massachusetts, as well as one of the best lake populations of triangle floater.

In the summer of 2009, landowners around Mystic Lake began to see an unusually large number of mussels dying and washing ashore. This die-off began in early August and quickly escalated, reaching a peak by mid-month. The event was preceded by an unusually wet period during June and July. This was followed by particularly warm air temperatures and a rapid increase in algal turbidity in the lake. The



Two adult and one juvenile tidewater mucket from Mystic Lake.

die-off seemed to be primarily confined to the mussel population, though residents reported seeing small numbers of dead fish. Underwater video revealed remarkably high mussel mortality in deep water, similar to the mortality observed in shallow water.

In early 2010, Biodrawversity LLC was contracted by the Natural Heritage and Endangered Species Program (NHESP) to repeat the 2007 mussel survey, determine the magnitude of the mussel die-off, and provide a status report for state-listed mussel populations in Mystic Lake (Biodrawversity 2010b). The

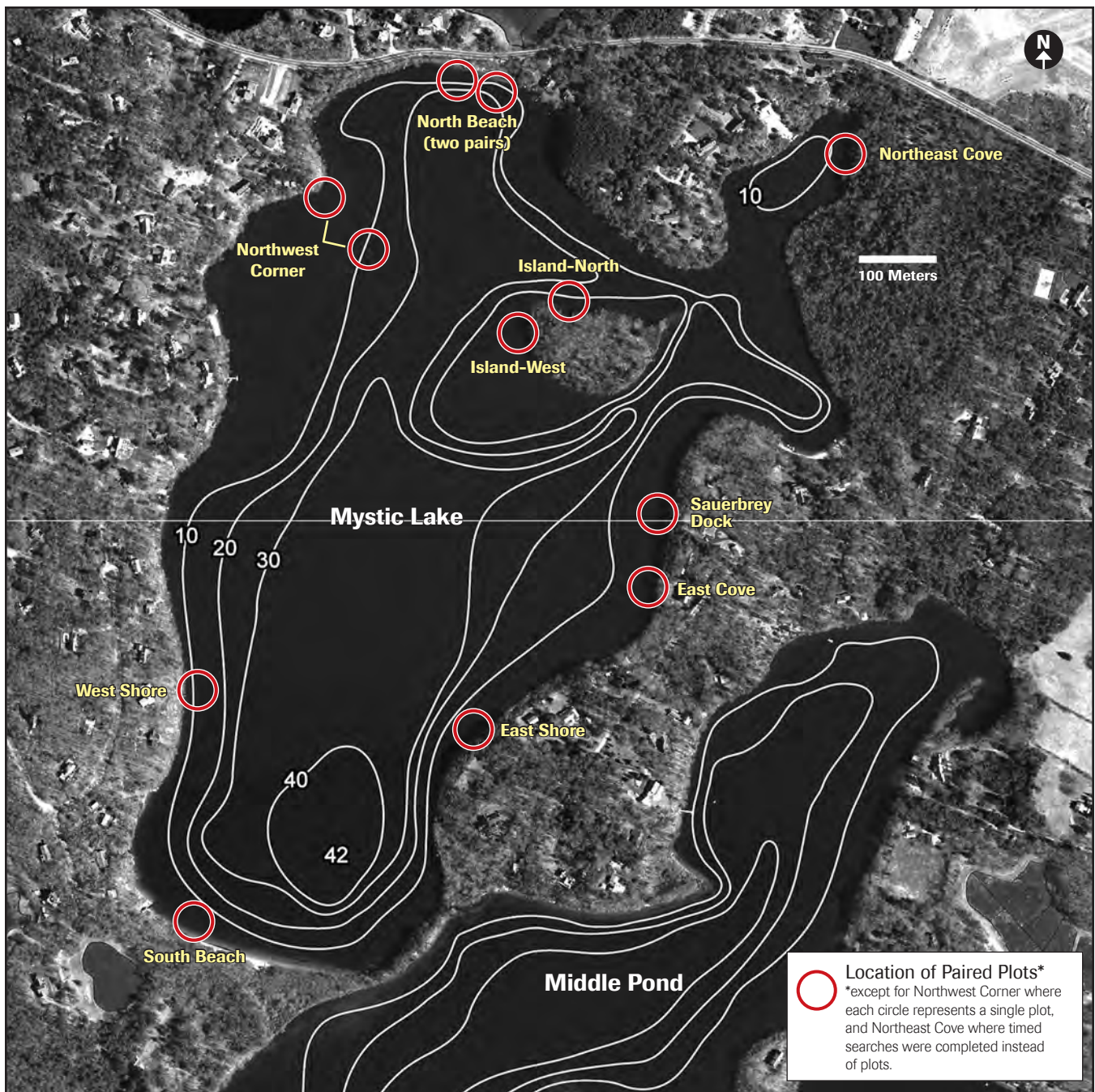


Figure 1. Survey locations for the 2007, 2010, and 2011 mussel surveys in Mystic Lake.

2010 survey (conducted in June) also established a new baseline prior to the alum treatment that occurred in September 2010. Unfortunately, another mussel die-off occurred in August-September of 2010, after the baseline study was carried out but before the alum treatment began (in September), meaning that the alum treatment occurred without an updated baseline for the mussel population.

Prior to, during, and after the alum treatment, Biodrawversity biologists also monitored mortality

and behavior of freshwater mussels that had been placed in enclosures within both treatment areas and control areas (Biodrawversity 2011); this study did not detect significant short-term responses of mussels to the treatment. As part of the conditions of the permit to treat Mystic Lake with alum, NHESP required a one-year follow-up survey to check for response(s) of the mussel community to the alum treatment. Clearly, mortality associated with the 2009 and 2010 die-offs, with potential effects that may take years or

Table 1. Names, locations, and survey years for each of the survey location in Mystic Lake.

Location	Plot	Latitude	Longitude	Year(s) Surveyed
Sauerbrey Dock	Shallow	41.679216	-70.411594	2007
	Deep	41.679255	-70.411862	2007
East Cove	Shallow	41.678409	-70.411826	2007, 2011
	Deep	41.678431	-70.412003	2011
West Shore	Shallow	41.677235	-70.418999	2007, 2010, 2011
	Deep	41.677209	-70.418800	2007, 2010, 2011
Island-West	Shallow	41.681297	-70.413786	2007, 2010, 2011
	Deep	41.681300	-70.413903	2007, 2010, 2011
Northwest Corner	Shallow	41.683026	-70.416821	2007, 2010, 2011
	Deep	41.682256	-70.416060	2007, 2010, 2011
North Beach (Pair 1)	Shallow	41.684177	-70.414078	2007, 2010, 2011
	Deep	41.684103	-70.414155	2007, 2010, 2011
North Beach (Pair 2)	Shallow	41.684259	-70.414539	2007, 2010, 2011
	Deep	41.684182	-70.414593	2007, 2010, 2011
Island-North	Shallow	41.681550	-70.413146	2007, 2010, 2011
	Deep	41.681707	-70.413119	2007, 2010, 2011
South Beach	Shallow	41.674352	-70.419092	2007, 2010, 2011
	Deep	41.674588	-70.418740	2007, 2010, 2011
Northeast Cove	General Area	41.68320	-70.40871	2010, 2011
East Shore	Shallow	41.67647	-70.41485	2010, 2011
	Deep	41.67656	-70.41508	2010, 2011

decades to be realized, are now confounded with any potential long-term effects of the alum treatment. Thus, this report describes current conditions and compares them to prior data, but draws no conclusions about the effects of the alum treatment.

METHODS

A standard survey technique was used at most of the survey locations in 2007, 2010, and 2011 (Figure 1, Tables 1-2). A pair of 5m x 5m plots was sampled at each location. For each pair of plots, one was set up in shallow water (0.5-1.5 meters) and surveyed by snorkeling, while the other was set up in deep water (2.5-5.5 meters) and surveyed by SCUBA diving. Plots were marked by a pair of 5-meter ropes attached in the middle and weighted on each end. Each plot was surveyed for a 30-minute period. All live state-listed mussel species encountered in the 30-minute search were counted and measured, and the degree of shell erosion was described for each measured animal. During the 2007 survey, only state-listed species were counted because other species were far too numerous to count. In 2010 and 2011, total mussel numbers were much lower and surveyors recorded precise counts of all species. GPS coordinates of the centerpoint of each plot were recorded in 2007 and 2010, allowing follow-up surveys to be conducted at exactly the same points. In addition to the plot data, brief excursions into deep water were conducted at

several points in the lake to determine which species were present and at what densities.

- **2007:** A total of 17 5m x 5m plots were surveyed in 2007. These plots were established in nine different locations around the lake (8 with pairs, a ninth with a single plot).
- **2010:** The 2010 survey generally repeated the 2007 survey, except that three of the 2007 plots (from two locations) were not resurveyed. In lieu of the three plots not resurveyed, two pairs of plots and two 30-minute timed searches were added in the northeastern cove (which had never been surveyed prior to 2010) and along the southeastern shoreline.
- **2011:** A total of 20 plots were surveyed in 2011. We surveyed the same plot locations as in 2010, and revisited two plots in the east cove not surveyed since 2007. In addition, the two unconfined 30-minute surveys conducted in 2010 in the northeastern cove were repeated.

RESULTS

I. 2007 Lake-wide Survey

In 2007, a total of 529 tidewater mucketts, 10 triangle floaters, and 9 eastern pondmussels were counted within 17 25m² plots (Table 2). Surveyors

Table 2. Mussel count data for state-listed mussels and all species combined at 11 locations (20 plots and 1 timed search) in Mystic Lake. See Table 1 for GPS coordinates and Figure 1 for general locations.

Location	Plot	All Species			Tidewater Muckets			Triangle Floaters			Eastern Pondmussels		
		2007	2010	2011	2007	2010	2011	2007	2010	2011	2007	2010	2011
Sauerbrey Dock	Shallow	>200	-	-	27			5			0		
	Deep	>200	-	-	46			1			2		
East Cove	Shallow	>200	-	4	35		0	1		0	0		0
	Deep	-	-	2	-		0	-		0	-		0
West Side	Shallow	>200	<10	0	12	1	0	0	0	0	1	0	0
	Deep	>200	>200	10	34	0	0	1	0	0	0	0	0
Island West	Shallow	~100	20-30	0	4	4	0	0	0	0	0	0	0
	Deep	>500	>500	7	38	2	0	0	0	0	0	0	0
Northwest Corner	Shallow	13	3	1	0	0	0	0	0	0	0	0	0
	Deep	>500	<100	1	42	0	0	0	0	0	1	0	0
North Beach	Shallow	>200	<10	1	42	0	0	0	0	0	0	0	0
	Shallow	>200	20-30	1	47	0	0	0	1	0	0	0	0
	Deep	>500	100-150	3	27	0	0	0	0	0	2	0	0
	Deep	>200	150-200	8	8	1	0	0	0	0	0	0	0
Island-North	Shallow	>200	<100	7	38	10	1	0	0	0	0	0	0
	Deep	>500	<100	17	18	0	0	1	0	0	0	0	0
South Beach	Shallow	>200	<10	2	88	2	0	1	2	0	0	0	0
	Deep	>200	20-30	13	23	0	0	0	0	0	3	0	0
Northeast Cove	General	-	>200	10		0	0		2	0		0	0
East Shore	Shallow	-	30-50	2		11	0		4	0		0	0
	Deep	-	>500	12		0	0		0	0		0	0
Total		-	-	101	529	31	1	10	9	0	9	0	0
Average Per Plot		~400	~125	5.316	31.118	1.824	0.053	0.588	0.529	0.000	0.500	0.000	0.000
Average Per Square Meter		~15-20	~5	0.213	1.245	0.073	0.002	0.024	0.021	0.000	0.020	0.000	0.000

counted an average of 31.1 tidewater muckets per plot (range = 0-88, standard deviation = 20.8). Tidewater mucket densities exceeded 25/plot (i.e., one per square meter) in 10 of the 17 plots, and there were some patches with densities exceeding 10/m². The average shell length of tidewater muckets was 67.5 (n = 470, standard deviation = 10.25, range = 25-92 mm). Densities of triangle floaters and eastern pondmussels were similar to each other and very low compared to other species.

Surveyors often estimated total population sizes (all mussels combined) well in excess of 500 mussels per plot. Although specific population counts were not made for common mussel species (generally because these animals were too numerous to count, and such data were not necessary to meet objectives of the survey), observations suggest that eastern elliptio and eastern lampmussels were the two most abundant species. An exception to this pattern was that tidewater muckets were often more numerous than eastern lampmussels in shallow, sandy environments. Mussel densities were highest in depths of 0.5-4.5 meters; there was a precipitous decline in density (and diversity) from 4.5-6.0 meters. The lakebed out to the 6.0-meter contour line supported perhaps more than 99 percent of all tidewater muckets, eastern pond-

mussels, and triangle floaters in the lake. Extrapolating from the average mussel density within plots, the 2007 report estimated lake-wide population sizes of 339,711 tidewater muckets, 18,195 triangle floaters, and 19,650 eastern pondmussels.

II. 2010 Lake-wide Survey

In 2010, only 31 live tidewater muckets and 9 live triangle floaters were counted within 16 plots. No live eastern pondmussels were detected. Shell (dead animal) counts within plots totaled 491 tidewater muckets, 11 triangle floaters, and 10 eastern pondmussels. Surveyors counted an average of 1.82 tidewater muckets per plot (range = 0-11). Live tidewater muckets were absent in 9 of the plots. The average shell length of tidewater muckets was 55.6 (n = 31, standard deviation = 9.9, range = 31-75mm). The density of triangle floaters was very low. Triangle floaters were absent in 13 of the plots, and four of the nine observed were found within a single plot. The shallow plot along the eastern shore contained the highest number of tidewater muckets and triangle floaters among all plots while its deep pair contained the highest density of eastern elliptio. Exact counts of all mussel species were recorded for each plot in 2010 because densities were low enough to make precise

counts feasible. Eastern elliptio were still common in some areas of the lake, with counts exceeding 100 animals in seven plots and 500 animals in two of the plots. Numbers of eastern elliptio were generally higher in rocky areas of the eastern shoreline.

III. 2011 Lake-wide Survey

In 2011, counts were extremely low for all mussel species in Mystic Lake. The only state-listed species observed in 18 plots was a single tidewater mucket. This one mucket was located on the north side of the island in the northern part of the lake. No live triangle floaters or eastern pondmussels were observed in Mystic Lake, although shells of both species were found. Eastern elliptio continued to be the most common mussel species encountered in the lake, with a total of 84 found. Plot counts ranged from zero to 16 with an average of 4.4 mussels per plot. The second most common species in Mystic Lake was alewife floater (*Anodonta implicata*), with a total of 12 mussels found. Plot counts ranged from zero to five for this species, and averaged only 0.7 mussels per plot. The third most encountered species was eastern lampmussel (*Lampsilis radiata radiata*); however, only four were found, with one individual occurring in four of the 18 plots, for an average of 0.2 mussels per plot. The highest mussel densities encountered were at the pair of sites north of the island, where seven mussels were found in the shallow plot and 17 were observed in the deep plot.

IV. Comparing 2007, 2010, and 2011 Results

We calculated a 94.1 percent reduction in Mystic Lake's tidewater mucket population from 2007 to 2010, and a 99.8 percent reduction from 2007 to 2011. No area of the lake, nor any depth, seems to have been spared from heavy mortality for this species. In both 2010 and 2011, some plots were carefully excavated to determine if juvenile mussels persisted through the die-off, but these efforts revealed very few animals. In 2010, most of the buried animals found were dead (they had clearly died in place because they were in an otherwise natural position and black rotting tissues were often still contained within the shells). No juvenile muckets were found in 2011, and only a handful of juvenile alewife floater were uncovered. The shallow plot along the south beach, where 88 live tidewater muckets were found in 2007, yielded only two live tidewater muckets

(and 133 dead animals) in 2010, and none were found here in 2011. Average shell length of the live tidewater muckets counted in 2010 was lower than it was in 2007 (67.5 mm vs. 55.6 mm), suggesting that smaller animals may have been more likely to survive the die-off, although higher sample sizes in 2010 would have increased our confidence in that observation. The single tidewater mucket found in 2011 was 57 mm in length.

We did not detect a statistically significant change in the triangle floater population from 2007-2010, but no live triangle floaters were observed in 2011. Sample sizes were very small in all years, however, and results may not necessarily reflect true population change. The same is true for eastern pondmussels; we computed a 100 percent reduction (9 in 2007, 0 in 2010, and 0 in 2011) but are unsure if these data indicate extirpation. Nevertheless, the population is probably very small and near or below detection limits for most types of surveys.

Extrapolating from the average mussel density within plots, the 2007 report estimated lake-wide population sizes of 339,711 tidewater muckets, 18,195 triangle floaters, and 19,650 eastern pondmussels. In contrast, results from the 2010 fieldwork were used to compute lake-wide population sizes of 18,777 tidewater muckets, 5,458 triangle floaters, and zero eastern pondmussels for that year. Our estimates for 2011 are lower still, with lake-wide population sizes of 607 tidewater muckets, zero triangle floaters, and zero eastern pondmussels. These data suggest a 99.8 percent reduction of tidewater mucket from 2007 to 2011, and possible extirpation of eastern pondmussel and triangle floater. Very few live eastern floaters, alewife floaters, and eastern lampmussels were found in 2010 or 2011, suggesting that these species may have experienced similar mortality rates as the three state-listed species.

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