Freshwater Mussel Survey in Middle Pond and Hamblin Pond (Barnstable, Massachusetts)

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In 2011, freshwater mussel surveys were conducted in Hamblin Pond and Middle Pond in Barnstable, Massachusetts, at the request of the Indian Ponds Association. On June 2, Biodrawversity biologists carried out a survey in Hamblin Pond to determine if mussels existed in the pond. Prior surveys had not detected any mussels in Hamblin Pond yet their absence seemed unlikely because nearby ponds (Middle Pond and Mystic Lake, Figure 1) contained large mussel populations. On June 3, the same biologists conducted a survey in Middle Pond, specifically to assess mussel densities throughout the pond and to evaluate the condition of the state-listed tidewater mucket (*Leptodea ochracea*), eastern pondmussel (*Ligumia nasuta*), and triangle floater (*Alasmidonta undulata*) populations that were documented there in 2007 (Biodrawversity 2008). The survey in Middle Pond was prompted by reports of mussel die-offs in Middle Pond and the adjacent (and connected) Mystic Lake in 2009 and 2010. The die-offs in Mystic Lake were investigated in 2010 and 2011 (Biodrawversity 2010, 2011), and it was determined that the tidewater mucket population declined by 99.8 percent from 2007 to 2011, and both eastern pondmussel and triangle floater may have been extirpated. Species occurrence, population densities, age demographics (inferred from size distribution), and shell conditions were evaluated for all mussels to document changes in these parameters since the last survey.

Figure 1. Mystic Lake, Middle Pond, and Hamblin Pond in Barnstable, Massachusetts.

Figure 1. Survey locations for the 2007 and 2011 mussel surveys in Middle Pond and Hamblin Pond.

METHODS

Hamblin Pond

Two areas were surveyed in Hamblin Pond (Figure 1). Area 1 extended for 360 meters along the northern shore of the pond. Area 2 extended for 250 meters along the southern shore near the swimming area. Two biologists surveyed each area for 1.5 hours (three total search hours per area) using SCUBA and snorkel equipment. The survey was confined to depths shallower than eight meters, on the assumption that if mussels existed in deeper areas that they would also be present in shallower areas.

Middle Pond

Surveys in Middle Pond occurred at previously studied locations (Biodrawversity 2008) as well as five additional locations around the lake (Figure 1, Table 1). At each location, surveyors established a pair of 25m^2 quadrats. One of each pair was located in shallow water (<1 meter) and surveyed using snorkel equipment, and the other was located in deeper water (2-5 meters) and surveyed using SCUBA equipment. The pairs were usually within 30 meters of each other.

Within each quadrat, all eastern elliptio (*Elliptio complanata*) were counted. Additionally, all other mussel species were counted and measured, and shell

Table 1. Locations of the quadrats in Middle Pond and years that they were surveyed.

Location	Quadrat	2007 Site Designation	Years Surveyed	Longitude	Latitude
1	Shallow	MP1	2007, 2011	-70.40738	41.67810
1	Deep	MP2	2007, 2011	-70.40738	41.67810
2	Shallow	-	2011	-70.41036	41.67706
2	Deep	-	2011	-70.41028	41.67699
3	Shallow	MP3	2007, 2011	-70.41095	41.67481
3	Deep	MP4	2007, 2011	-70.41095	41.67481
4	Shallow	MP7	2007, 2011	-70.41562	41.67392
4	Deep	MP8	2007, 2011	-70.41562	41.67389
5	Shallow	-	2011	-70.41842	41.67238
5	Deep	-	2011	-70.41832	41.67238
6	Shallow	MP9	2007, 2011	-70.41782	41.66920
6	Deep	MP10	2007, 2011	-70.41754	41.66932
7	Shallow	-	2011	-70.41373	41.67030
7	Deep	-	2011	-70.41348	41.67029
8	Shallow	MP5	2007, 2011	-70.41326	41.67237
8	Deep	MP6	2007, 2011	-70.41343	41.67254
9	Shallow	-	2011	-70.41000	41.67309
9	Deep	-	2011	-70.41003	41.67317
10	Shallow	-	2011	-70.40868	41.67485
10	Deep	-	2011	-70.40901	41.67492

conditions were characterized by the degree of shell erosion (light (0), medium (0.5), or heavy (1.0)). Habitat conditions such as water depth, substrate type, presence of woody debris, and percent coverage of rooted plants were also measured and recorded for each quadrat.

RESULTS

Hamblin Pond

No mussels (live or dead) were found during the Hamblin Pond survey. Substrate throughout both survey areas was a combination of sand and gravel; this substrate type provides ideal habitat for freshwater mussels and is also present in nearby lakes that do have mussel populations. Given the suitable habitat conditions and the lack of any mussels found in the survey, or in prior surveys, it is doubtful that any mussels are present within Hamblin Pond.

Middle Pond

Live animals of five species were found in Middle Pond, including (in order of abundance) eastern elliptio, tidewater mucket, eastern lampmussel (*Lampsilis radiata*), eastern floater (*Pyganodon cataracta*), and triangle floater. Only one of the 20 quadrats lacked mussels (Table 2). Species richness per quadrat ranged from zero to five. Unlike during prior surveys, neither live eastern pondmussels nor live alewife floater (*Anodonta implicata*) were found during this survey.

Tidewater Mucket: Tidewater muckets were found in 14 of the 20 quadrats, and a total of 135 animals were found. In quadrats where they were found, numbers ranged from 1–34, and the average density among all quadrats was 6.75 (Table 2). Of the six quadrats that lacked tidewater muckets, four were in shallow water and two were in deep water. Average shell length was 53.0 mm (range = 38–78 mm) (Table 3). Average shell condition was 0.77 (Table 3), indicating high levels of shell erosion.

Triangle Floater: A single animal was found in each of three quadrats. Shell lengths were 45, 47, and 50 mm. Average shell condition was 0.17, indicating light shell erosion.

Eastern Lampmussel: This species was found in 17 of the 20 quadrats. A total of 83 individuals were found and counts ranged from 0–11 per quadrat (average = 4.15 per quadrat). Average shell length was 60.0 mm (range = 44–73 mm). Average shell condition was 0.47, indicating moderate levels of shell erosion.

Table 2. Mussel counts and summary statistics for quadrats surveyed in Middle Pond in 2007 and 2011. See Table 1 and Figure 1 for locations.

		Species Counts[1,2]															Species Richness	
		LeOc		LiNa		AlUn		ElCo		LaRa		PyCa		AnIm		All		
Location	Quadrat	2007	2011	2007	2011	2007	2011	2007	2011	2007	2011	2007	2011	2007	2011	2011	2007	2011
1	Shallow	25	1	1	0	0	0	P	7	P	2	P	0	P	0	10	6	3
1	Deep[3]	21	1	22	0	0	0	P	25	P	1	P	1	P	0	28	6	4
2	Shallow	-	1	-	0	-	0	-	31	-	2	-	0	-	0	34	-	3
2	Deep	-	6	-	0	-	0	-	67	-	8	-	0	-	0	81	-	3
3	Shallow	31	0	0	0	0	0	P	41		1	P	0	P	0	42	4	2
3	Deep	192	13	6	0	2	0	P	40	P	2	P	0	P	0	55	7	3
4	Shallow	26	0	2	0	0	0	P	12	P	1	P	0	P	0	13	6	2
4	Deep	252	9	22	0	0	0	P	157	P	9	P	1	P	0	176	6	4
5	Shallow	-	0	-	0	-	0	-	3	-	7	-	0	-	0	10	-	2
5	Deep	-	0	-	0	-	0	-	25	-	4	-	0	-	0	29	-	2
6	Shallow	70	1	4	0	3	0	P	3	P	0	P	0	P	0	4	7	2
6	Deep	90	5	4	0	0	0	P	59	P	4	P	2	P	0	70	6	4
7	Shallow	-	0	-	0	-	0	-	8	-	0	-	0	-	0	8	-	1
7	Deep	-	0	-	0	-	0	-	0	-	0	-	0	-	0	0	-	0
8	Shallow	13	34	0	0	0	1	P	152	P	11	P	0	P	0	198	3	4
8	Deep	130	11	2	0	0	0	P	16	P	6	P	0	P	0	33	6	3
9	Shallow	-	9	-	0	-	0	-	71	-	10	-	1	-	0	91	-	4
9	Deep	-	24	-	0	-	1	-	10	-	6	-	1	-	0	42	-	5
10	Shallow	-	10	-	0	-	0	-	14	-	7	-	1	-	0	32	-	4
10	Deep	-	10	-	0	-	1	-	195	-	2	-	0	-	0	208	-	4
Total Mussel Counts in Quadrats		829	135	41	0	5	3	P	936	P	83	P	7	P	0	1164	-	-
Average Density (mussels per quadrat)		92.11	6.75	4.55	0	0.56	0.15	-	46.8	-	4.15	-	0.35	-	0	58.2	-	-
Percent Change in Mussel Density		92.7		100		73		-		-		-		-		-	-	-
Average Species Richness		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.7	2.95

1. LeOc = *Leptodea ochracea*, LiNa = *Ligumia nasuta*, AlUn = *Alasmidonta undulata*, ElCo = *Elliptio complanata*, LaRa = *Lampsilis radiata*, PyCa = *Pyganodon cataracta*, AnIm = *Anodonta implicata*
2. P = Present. These species were not counted in 2007.
3. The 2007 survey at this location was an unconfined 30-minute timed search (not a quadrat) and results are not included in the density calculations.

Table 3. Shell length and shell condition data for 2007 and 2011.

	Species[1]							
	LeOc		LiNa		AlUn		LaRa	PyCa
Year	2007	2011	2007	2011	2007	2011	2011	2011
Sample Size	348	135	48	0	4	3	83	7
Average Shell Length (mm)	53.0	53.3	60.4	-	37.0	47.3	60	83.9
Min Shell Length (mm)	29.0	38.0	41.0	-	34.0	45.0	44	58.0
Max Shell Length (mm)	80.0	73.0	75.0	-	41.0	50.0	73	109.0
Shell Condition Index	0.22	0.77	0.19	-	0.00	0.17	0.47	0.39

1. Species abbreviations as in Table 2.

Eastern Floater: This species occurred in six of the 20 quadrats but only seven animals were found in total and no more than two were found in any single quadrat. Average shell length was 83.9 mm (range = 58–109 mm). Average shell condition was 0.39, indicating light to moderate levels of shell erosion.

Eastern Elliptio: This species was found in 19 of 20 quadrats. A total of 936 animals were counted and numbers per quadrat were as high as 195, with an average of 46.8 per quadrat. Neither shell length nor shell condition was recorded.

DISCUSSION

In Middle Pond, mussel diversity and density declined within almost all quadrats between 2007 and 2011. Species richness of live mussels dropped from seven to five, and average species richness per quadrat dropped from 5.6 to 2.9. It is likely that two species not detected in 2011—alewife floater and eastern pondmussel—do still occur in Middle Pond, but are only present at much lower densities and are therefore more difficult to detect with quantitative surveys and limited sample sizes.

The 2007 survey was focused only on state-listed mussels (tidewater mucket, eastern pondmussel, and triangle floater) and some of the other species were considered too numerous to count. Therefore, we cannot determine the magnitude of the decline in densities of the four species that were not precisely counted in 2007. Generally, we feel that the alewife floater, eastern floater, eastern lampmussel, and eastern elliptio populations experienced 85–95 percent mortality over the time period based on the relative abundances estimated in 2007 (Biodrawversity 2008). For example, eastern elliptio was ranked as the most numerous species (by far) in 2007, often 5-10 times more numerous than all other species, yet in 2011 it was approximately one-half less abundant than tidewater muckets were in 2007. Similarly, eastern lampmussels and tidewater muckets were considered to have very similar densities in 2007, and in 2011 eastern lampmussels were less common than tidewater muckets (4.15 vs. 6.75 mussels per quadrat), suggesting a decline similar or greater in magnitude than tidewater muckets. In 2011, average mussel density in quadrats for all species combined was 58.2, which is 37 percent lower than the density of tidewater muckets alone in 2007.

Tidewater Mucket: Both in 2007 and 2011, tidewater muckets were distributed throughout the lake, occurring in 90 and 70 percent of the quadrats in the two years, respectively. Densities declined from 92.1 to 6.75 mussels per quadrat from 2007 to 2011, a 92.7 percent decline. A total of 829 tidewater muckets were counted or estimated in nine quadrats in 2007, compared to only 135 individuals in 20 quadrats in 2011. Average shell length was the same in 2007 and 2011 (53.0 mm), but the shell condition index increased from an average of 0.22 (sample size = 348) in 2007 to 0.77 (sample size = 135) in 2011. This is an astounding and unprecedented degradation of shell condition in such a short time period, and we do not know why there was such a rapid loss of periostracum and underlying shell material.

Eastern Pondmussel: A total of 63 live eastern pondmussel were found in 2007, including 41 that were distributed among six of the nine quadrats and 22 that were found in an unconfined search at Site 1. None were found in the 20 quadrats surveyed in 2011, representing a 100 percent decline. Shells collected in 2011 exhibited very poor shell condition, similar to the tidewater muckets. Eastern pondmus-

Top: A catch of tidewater muckets from one of the quadrats in 2007. The range of shell conditions, generally in the light-medium range, are shown here. Right: In 2011, most of the tidewater muckets had lost 50-90 percent of the periostracum and underlying shell material and could easily be crushed by applying light pressure on the shells.

sel may still occur in Middle Pond, but only at very low densities if so, and considering trends for other species, extirpation might be imminent.

Triangle Floater: Five live triangle floater were found in Middle Pond in 2007, for an average of 0.56 per quadrat. Only three were found in 2011, for an average of 0.15 per quadrat. Such low sample sizes in both years preclude a meaningful analysis of either density or demographics. Given the decline of all other species in Middle Pond, extirpation might be imminent for its triangle floater population

The steep level of decline recorded for populations of state-listed mussels and co-occurring mussel species in Middle Pond raises significant concern about their future presence at this location. The summary report for the 2007 field study concluded that Middle Pond "…may be the single best pond in Massachusetts and the entire Northern Atlantic Slope in terms of freshwater mussel diversity and abundance." The connected Mystic Lake was considered second best. In less than four years, there has been a greater than 90 percent reduction in numbers of nearly all spe-

cies in these two lakes (see Biodrawversity 2010 and 2011 for documentation on Mystic Lake). This decline has been the result of late summer mussel die-offs, the causes of which remain unknown. In Middle Pond in 2011, two more late-summer die-off periods were observed after this field survey was completed, and thus current population numbers are likely even lower than reported here. The small and dwindling populations of mussels that remain in these lakes may not be able to recover. We recommend annual monitoring to further understand population trends, creative thinking about ways to preserve the mussel fauna of Middle Pond and Mystic Lake, and a full suite of chemical and biological testing to determine the causes of the recent mussel die-offs.

REPORTS CITED

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