

Mill Brook Aquatic Biomonitoring 22-23

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Sampling sites and methodology

Eight sites were sampled for macroinvertebrates on a monthly basis beginning March, 2022 and ending February 2023. Two sampling methods were used. Sites were “swept” using an aquatic D-frame dip net. Sweeping consisted of moving the net across the stream bottom, as well as through aquatic macrophytes, stick piles, and undercut banks to collect macroinvertebrates. Rocks were also flipped and rubbed by hand to dislodge any macroinvertebrates, which were then scooped up by the dipnet. Sites were also sampled using a kick-net, which consists of using one's feet to dislodge rocks and sediment from the stream bottom. Dislodged material is carried downstream into the net. Both sampling methods were conducted at two-minute intervals. Collected material was checked on site for the presence of macroinvertebrates. Collected material was then preserved in 70% ethanol and stored until sorted/identified.

Macroinvertebrates were identified to the lowest possible taxonomic level using current keys (species for most groups, genus for those groups for which species-level keys do not exist). Identified specimens are stored in glass vials containing 70% ethanol. Voucher specimens will be stored on Martha's Vineyard.

Mill Brook sites (in order from headwaters to the most downstream site below Mill Pond) consisted of MB1, MB2, MB8, MB4, MB5 (there were two MB5 sites, MB5 and MB5s, they are combined in this report as simply MB5) and MB6. Witch Brook was referred to as MB9 and flows into Crocker Pond.

Known issues

There are six impoundments of various sizes along the length of Mill Brook. Each impoundment impedes flow, negatively affects the downstream distribution of nutrients, traps sediment, increases temperature, and blocks or impedes the upstream passage of fish and the downstream drift of aquatic macroinvertebrates. The ponds found on Mill Brook are currently valued for aesthetic purposes only. They are not utilized for flood control purposes or for maintaining rare or critical habitat.

Impoundments:

Fisher Pond: 10.4 acres

Crocker Pond: 7.8 acres

Priester's Pond: 4 acres

Berresford's Pond: 0.10 acres

Albert's Pond: 1.8 acres

Mill Pond: 2 acres

MB2 site: There are perched undersized culverts present at Roth Woodlands just upstream from the MB2 site. The perched nature of the culverts prevents stream flow during periods of low flow. Water and sediment back up on the upstream side of the culverts, raising water temperature. Downstream drift of macroinvertebrate larvae is blocked, as is up/downstream migration of fish.

MB5 site: The remains of the Whiting Diversion Dam is located between the MB5 and MB5s sites. It is an impediment to upstream fish migration, but not to macroinvertebrate downstream drift.

Priester's Pond: This artificial pond experiences seasonal influxes of nutrients from local farmland located along Mill Brook and the unnamed feeder stream MB10. The pond is shallow, warm and attracts large amounts of geese. The dam slows water flow, traps sediment, and warms the water. The dam also blocks the upstream migration of fish. The pond blocks the downstream drift of certain sensitive species of macroinvertebrates.

MB10 site: an unnamed feeder stream that flows into Priester's Pond. MB10 was not sampled for macroinvertebrates during this study, but was sampled by the author in 2008. This stream experiences a seasonal influx of nutrients from local farmland located along the stream.

Fisher Pond, Crocker Pond, Mill Pond: All three ponds are artificial, shallow and warm. The dams that create the ponds slow water flow, trap sediment, and result in thermal pollution. The dams also block the upstream migration of fish. The ponds block the downstream drift of certain sensitive species of macroinvertebrates. Several sensitive species of macroinvertebrates are not found downstream of Fisher pond.

Mill Brook experiences a shift from a cold-water fauna to a warm-water fauna within the span of a mile (from the MB1 site to the MB4 site). This shift is due to the presence of three artificial ponds with dams. These dams cause significant thermal pollution and limit the typical downstream drift patterns of certain sensitive species of macroinvertebrates. Elevated nutrient level (nitrogen and phosphorus) is evident in the MB9 site feeding into Crocker pond and the MB10 site feeding into Priester's Pond. This contributes to a substantial boost to the bottom-up food web in the ponds, resulting in an increased macroinvertebrate abundance starting with the MB4 site.

Macroinvertebrate analysis

Diversity and abundance were substantially higher than the previous round of sampling in 2018. Over 20,000 specimens from 111 species were collected and identified. This can be attributed to a revised sampling methodology and year-long sampling (previous sampling only occurred from May-August). Of the 111 species collected, 39 are new records for Mill Brook, and 46 are new records for Witch Brook.

MB1: 40 species identified, 6 species unique to the site. Coldwater site. Pre-pond site.

MB2: 17 species identified. 2 species unique to the site. Coldwater site. Pre-pond site

MB8: 36 species, 4 species unique to the site. Coldwater site. Pre-pond site.

MB4: 50 species identified, 7 species unique to the site. Warmwater site. Post-pond site

MB5: 52 species, 5 species unique to the site. Warmwater site. Post-pond site.

MB6: 63 species, 11 species unique to the site. Warmwater site. Post-pond site.

Witch: 50 species, 5 species unique to the site. Coldwater site. Pre-pond site.

There are several sensitive species that were collected from pre-pond sites that were either absent from post-pond sites or found in much lower abundance. Fisher Pond is the first of three small ponds along Mill Brook, and several species that are found upstream of Fisher Pond (MB1, MB2, MB8) are not found in any sites below the ponds. Witch Brook flows into Crocker Pond, and there are several species found in Witch Brook that are not found at sites downstream of Crocker Pond.

Mayflies:

Eurylophella funeralis: found in high abundance at MB8 and Witch Brook, low abundance at MB4 and MB6.

Stoneflies:

Leuctra ferruginea: found in high abundance upstream of Fisher Pond and in Witch Brook, low abundance in MB4, not found below MB4.

Leuctra maria: found in MB8 only.

Caddisflies:

Psilotreta frontalis: found upstream of Fisher Pond and at Witch Brook.

Rhyacophila carolina: found at MB8 and at Witch Brook.

Goera fuscula: found at Witch Brook.

Pycnopsyche gentilis: found at Witch Brook.

Goera betteni: found at Witch Brook.

Leptophlebia johnsoni: found upstream of Fisher Pond and at Witch Brook.

The negative effects of the ponds are evident. Macroinvertebrates exhibit various degrees of downstream drift over the course of their life cycles. When certain sensitive species drift into the ponds they cannot survive due to the change in environmental conditions. This places limits on the range and abundance of these species, as they can only utilize the pre-pond sections of the rivers. Several species of aquatic macroinvertebrates found on Martha's Vineyard have only been collected from specific sites in Mill Brook and Witch Brook. As such, any disturbances to these sites could result in a loss of biodiversity for Martha's Vineyard.

Two rare species were collected:

Epitheca spinosa, the Robust Baskettail dragonfly, was collected from the MB4 site. It is a southern coastal species ranging from Texas to New Jersey. It was also collected in 2008 from the MB 4 site by the author. Mill Brook represents the only record for this species north of New Jersey.

Goerita betteni (no common name found), a caddisfly, was collected from Witch Brook. It ranges from Tennessee to North Carolina, north to New York. This is a new record for Massachusetts, and Witch Brook represents the only record for this species north of New York.

Biotic Index

The Hilsenhoff Biotic Index (HBI) is a metric that uses the presence, abundance and tolerance values of macroinvertebrates found in flowing water to make determinations about water quality. HBI focuses on the effects of organic pollution, particularly how dissolved oxygen decreases as organic pollution increases. Calculated HBI values range from 0-10. The higher the value, the more organic pollution present in the water.

HBI Value	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	No apparent organic pollution
3.51-4.50	Very Good	Slight organic pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant organic pollution
6.51-7.50	Fairly Poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution
8.51-10.00	Very Poor	Severe organic pollution

Species are assigned a tolerance value between 0-10 based on their level of tolerance to organic pollution. The higher the assigned value, the more organic pollution a species can tolerate.

$$HBI = \frac{\sum n_i \times a_i}{N};$$

n = number of specimens in taxa i
 a = tolerance value of taxa i
 N = total number of specimens in sample

HBI values at sample sites ranged from 3.30 (excellent) to 5.42 (good). The overall value for Mill Brook was 4.51 (good) and the overall value for Witch Brook was 3.86 (very good). The MB8 site had the lowest value, while the MB4 site had the highest value:

MB1- 5.35 good

MB2- 4.58 good

MB8- 3.30 excellent

MB4- 5.42 good

MB5- 4.07 very good

MB6- 4.42 very good

Witch- 3.86 very good

MB2, MB8 and Witch Brook would be expected to have the lowest HBI values. They are cold-water sites that are conducive to sensitive macroinvertebrate species. The MB8 site did indeed have the lowest HBI value (3.30), while the MB2 site was significantly higher (4.58). The elevated HBI value at MB2 is the result of the perched culvert negatively affecting the overall biota and health of this section of river. The perched culvert (during periods of low flow) converts this section of river to an ephemeral site for a short distance downstream of the culvert, and an artificially warm and stagnant section upstream of the culvert. Sampling of MB2 was discontinued after the 6/22 sampling trip due to low flow conditions and the negative effects of the perched culvert.

The MB1 site has a higher HBI value (5.35) than most sites due to the high abundance of isopods and fingernail clams. The MB1 site has substrate conducive to these high-tolerance species. The author found even higher concentrations of isopods in equivalent discharge/substrate sites on Nantucket. The MB1 site is also home to several low-tolerance species of mayflies, caddisflies and stoneflies, so the 5.35 HBI value is not the result of decreased water quality due to organic pollution and can be considered artificially high when compared to the other sites. This anomaly is not seen in other sites, and at least on the islands of Martha's Vineyard and Nantucket appears to be limited to first-order, minimal discharge sites.

The MB4, MB5 and MB6 (post-dam sites) sites have higher HBI values than the MB8 and Witch Brook (pre-dam sites). This is attributed to the increased abundance of high-tolerance species at the MB4, MB5 and MB6 sites.

Water Chemistry

Dissolved oxygen, conductivity and pH do not appear to be limiting factors. Temperature (°C) is a clear limiting factor. Temperature increases dramatically throughout the course of the river. The temperature increase is most evident between MB8 (the last pre-pond site on Mill Brook) and MB4 (the first post-pond site), as well as between Witch Brook and the MB4 site (Witch Brook flows into the Crocker Pond impoundment of Mill Brook):

4/16/22: MB8 10.75°C, MB4 13.19°C = 2.44°C increase

5//15/22: MB8 14.60°C, MB4 20.34°C = 5.74°C increase

6/12/22: MB8 14.57°C, MB4 22.22 °C = 7.65°C increase

7/17/22: MB8 15.57°C, MB4 25.17°C = 9.60°C increase

8/14/22: MB8 14.64°C, MB4 22.50°C = 7.86°C increase

9/25/22: MB8 12.60°C, MB4 14.82°C = 2.22°C increase

10/23/22: MB8 11.99°C, MB4 13.40°C = 1.41°C increase

There is limited temperature data for Witch Brook:

7/17/22: Witch 17.94, MB4 25.17°C = 7.23°C increase

8/14/22: Witch 16.84, MB4 22.50°C = 5.66 °C increase

9/25/22: Witch 12.65°C, MB4 14.82°C = 2.17 °C increase

10/23/22: Witch 11.82°C, 13.40°C = 1.58 °C increase

A coldwater stream is classified as having summer temperature measurements (June-August) $\leq 20^{\circ}\text{C}$. This criteria is met at the pre-pond sites (MB1, MB2, MB8, Witch Brook), but not at any of the post-pond sites (MB4, MB5, MB6). The temperature increase is especially troubling considering it occurs within a distance of one mile. The increase has a clear negative impact on temperature sensitive species of macroinvertebrates. Those species adapted to coldwater streams are not able to survive the temperature increase induced by the ponds. Brook trout, which are native to Mill Brook, become stressed at temperatures above 20°C . The 25.17°C reading recorded in July at MB4 may even be lethal to brook trout, forcing them to find cooler temperature microrefugia between the Priester's Pond dam and Mill Pond. Mill Brook would be a coldwater stream for its entire length were it not for the impoundments.

What *should* the Mill Brook fauna be?

Prior to the implementation of the impoundments along Mill Brook, what would the original stream fauna have been? Mill Brook had a coldwater macroinvertebrate fauna along the entire length of the stream. The best on-island comparison would be Roaring Brook in Chilmark. Roaring Brook flows unimpeded and is a coldwater stream. Wild brook trout are found from the headwaters to the sea.

Roaring Brook was sampled for macroinvertebrates by the author in 2008 from March-October and exhibited a coldwater macroinvertebrate fauna. There are 33 species of macroinvertebrates found in both Roaring Brook and Mill Brook. The current known fauna of Roaring Brook stands at 60 species, well below the 111 collected from Mill Brook. There are several reasons for this. Mill Brook is longer, it has been sampled at more points along its length, it has been sampled year-round, and it has warm-water pond species in addition to typical stream species. The fauna of Roaring Brook would increase if it was sampled utilizing a protocol similar to that of the Mill Brook sampling protocol.

An HBI comparison between Roaring Brook and Mill Brook was calculated:

Roaring Brook HBI= 2.01 Excellent, March-October records only

Mill Brook HBI= 4.81 Good, March-October records only

An EPT Index (Ephemeroptera, Plecoptera, Trichoptera) was calculated for both streams.

Mayflies, stoneflies, and caddisflies are more sensitive to pollutants than are other groups of macroinvertebrates. The higher the % abundance value, the better the water quality:

Roaring Brook EPT Index 76.7% abundance

Mill Brook EPT Index 54.1% abundance

Overall, water quality is substantially higher in Roaring Brook. The lower HBI value is due to the stream fauna being dominated by low-tolerance species. Unimpeded coldwater stream habitats are more conducive to EPT fauna, hence the higher % abundance.

What would happen to the existing fauna of Mill Brook if the impoundments are removed?

Removal of the impoundments would cause Mill Brook to revert to a coldwater stream for its

entire length. Centuries of sediment would be swept downstream, riffle habitat would return. Brook trout would have unimpeded access from the headwaters to Tisbury Great Pond. The macroinvertebrate fauna would likely shift over time to a more cold-water fauna, similar to that of Roaring Brook. Overall, the health of the entire Mill Brook ecosystem would drastically improve.

Recommendations

- 1) Replace the perched culverts located upstream of the MB2 site at Roth Woodlands with one that allows normal stream flow and fish passage.
- 2) The ponds found on Mill Brook are currently valued for aesthetic purposes only. They are not utilized for flood control purposes or for maintaining rare or critical habitat. The ponds have a significant negative impact on the overall health of Mill Brook. Determine the feasibility of removing all dams/impoundments along Mill Brook.
- 3) Work with landowners to maintain/increase the riparian buffer along Mill Brook and Witch Brook.
- 4) Work with landowners to minimize nutrient pollution in Mill Brook, Witch Brook and the unnamed feeder stream.
- 5) Monitor water chemistry and discharge on a yearly basis.
- 6) Conduct macroinvertebrate sampling and electrofishing every 5 years. If water chemistry issues are noted, conduct macroinvertebrate sampling and electrofishing every 2-3 years.

*Species list, species abundance and tolerance values found on following pages.

	MB1	MB2	MB4	MB5	MB6	MB8	Witch	Tolerance value
Isopoda (sowbugs)								
<i>Caecidotea communis</i>	138	34	226	12	72	125	33	6
Ephemeroptera (mayflies)								
<i>Maccaffertium modestum</i>			37	295	187	6	67	6
<i>Eurylophella versimilis</i>	2	13	50	100	2	10	17	2
<i>Acerpenna pygmaea</i>	1		61	243	266		2	4
<i>Leptophlebia johnsoni</i> ***	9	3				22	10	4
<i>Heterocloeon anoka</i>					5			4
<i>Acentrella ralatoma</i>				41	8			4
<i>Eurylophella funeralis</i>			1		2	11	17	0
<i>Leptophlebia cupida</i>	4				1			4
<i>Pseudocloeon propinquum</i>	1			14	20		1	4
<i>Leptophlebia intermedia</i>			3	5	1	14	14	4
<i>Caenis latipennis</i>			20					7
<i>Heterocloeon amplum</i>					2			4
<i>Plauditus cestus</i>		32						4
<i>Paraleptophlebia mollis</i>					15			1
<i>Paraleptophlebia moerens</i>		4						1
Odonata (dragon/damselflies)								
<i>Enallagma durum</i>			5		7			8
<i>Boyeria vinosa</i>	2	1		1	8	2	11	2
<i>Enallagma signatum</i>					2			8
<i>Calopteryx maculata</i>			1	2	4			6
<i>Aeshna umbrosa</i> ***	2							5

<i>Ischnura posita</i>			3		12			9
<i>Epitheca spinosa</i>			1					5
Plecoptera (stoneflies)								
<i>Prostoia completa</i>	1		2	395	63	2		2
<i>Leuctra ferruginea</i>	2	20	22			340	39	0
<i>Taenopteryx nivalis</i>				118	144		1	2
<i>Leuctra maria</i>						210		0
<i>Prostoia similis</i>					5			2
<i>Taenopteryx maura</i>				64	44			2
<i>Paraleuctra sara</i>	28			18	4		10	0
<i>Ostracerca albidipennis***</i>	1							2
Amphipoda (shrimp)								
<i>Gammarus fasciatus</i>	1	122	194	194	99	190	12	6
<i>Hyalella azteca</i>	2		414		10			8
Trichoptera (caddisflies)								
<i>Ceraclea alagma</i>			24					3
<i>Cheumatopsyche sp.</i>			897	862	475			6
<i>Psilotreta frontalis</i>	7	4			1	18	9	0
<i>Chimarra obscura</i>			467	2	429			4
<i>Lepidostoma sp.</i>	3	10	9	67	82	8	65	1
<i>Hydropsyche ventura</i>			15	16	24			4
<i>Chimarra aterrima</i>	72		64	882	124		3	4
<i>Pycnopsyche guttifer</i>				4			1	4
<i>Hydropsyche betteni</i>			61	355	540	21	5	4
<i>Anabolia consocia</i>			6	3			6	4

Coleoptera (beetles)								
Macronychus glabratus adult			4	1	11			4
Macronychus glabratus			253	499	135		65	4
Stenelmis crenata			1540	429	591	1	50	5
Stenelmis crenata adult			3	6	23		1	5
Optioservus ovalis adult				16	15		16	4
Anchytarsus bicolor				3			29	5
Promoresia tardella adult				1			1	2
Promoresia tardela			3	270	75		18	2
Matus sp.***		4				1	4	5
Berosus sp.			1					5
Neoporus sp.***	1	3						5
Scrites sp.				1	3			5
Elodes sp.		1	2					5
Crenitis sp.						2		5
Peltodytes sp.			1		4			5
Agabus punctatus adult***	1							5
Neoporus undulatus adult***	2							5
Hydroporus ruficeps adult***	1							5
Peltodytes shermani adult					1			5
Enochrus ocharaceus adult	2			1	1			5
Bidessonotus longovalis adult					1			5
Hemiptera (true bugs)								
Trichocorixa calva	4			3				5
Rhagovelia obesa					5			5
Palmacorixa buenoi			2		1			5
Belostoma lutarium				2			1	9

Gerris sp.							1	5
Microvelia americana						1		5
Megaloptera (alderflies)								
Sialis iola	4				1	12	2	4
Diptera (flies)								
Tipula sp.			21	5		21	4	6
Prosimulium arvum	4		333	849	557	10	6	2
Simulium sp.	15		3	410	193	2	10	6
Chironomidae	62		876	186	145	267	148	6
Antocha sp.				9	3	84	14	4
Bittacomorpha clavipes						28		7
Silvius sp.***	1					75		5
Mallochohelea sp.***	2					1		6
Hemerodromia sp.					1			6
Sphaeriida (fingernail clams)								
Sphaeriidae	133	2	436	14	322	6	14	8
Gastropoda (snails)					7			7
Clitellata (leeches)	1		23	5	3	6	6	7
Lepidoptera (moths)								
Parponyx sp.				4				5
Petrophila sp.			1		1			5
Crambidae	1							5

Number of species	38	16	48	51	61	36	50	
Unique species	5	2	7	4	11	4	5	
*** Not found below dams (15)								