Investigating Thermal Attributes of the Shepaug River and Streams in Steep Rock Association Preserves

Steep Rock Association
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Overview

The objectives of this study were to 1) apply the Connecticut Department of Energy and Environmental Protection's (DEEP) thermal classifications to the Shepaug River and streams flowing through Steep Rock Association (SRA) preserves and to 2) explore the effects of brook confluence on the temperature of the Shepaug River. This information allows for a standardized classification of waterways and better understanding of thermal regimes to be applied to preservation and stewardship initiatives as they relate to water conservation.

Methods

The primary source of information for this capstone project was publicly sourced datasets managed by the Spatial Hydro-Ecological Decision System (SHEDS). This data was accessed online using the SHEDS Stream Temperature Public Data Viewer, which stores information collected by a range of organizations across the northeastern United States. Hourly temperature data collected by organizations such as DEEP and Housatonic Valley Association (HVA) at various locations ("stations") in the Shepaug River watershed at both Hidden Valley Preserve and Steep Rock Preserve was identified and isolated. Extraneous data was removed such that only hourly temperature data between June 1 and August 31 was sorted by year. The summer mean temperature and July mean temperature were calculated for each year. Yearly data was then analyzed to calculate the maximum daily mean for each year in each location. These values were compiled into a single spreadsheet so that comparison over time could be made and the water at each station could be classified as either "Cold," "Cool/Transitional," or "Warm" as per DEEP thermal classification ranges.

	Water Temperature (°C)		
Thermal Class	Summer Mean	July Mean	Maximum Daily Mean
Cold	<18.29	<18.45	<22.40
Cool/Transition	18.29-21.70	18.45-22.30	22.40-26.30
Warm	>21.70	>22.30	>26.30

The second facet of this study was to perform field checks on currently deployed SRA temperature loggers using water quality monitoring procedures provided by the DEEP Volunteer Stream Monitoring Network (V-STEM). For this component of the capstone, coordinates and a handheld GPS were used to locate temperature loggers at various locations. Once these loggers were located, a YSI Temperature Probe was used to record water temperature at the site. Temperature and time of day were recorded for cross-checking of data once loggers are collected and data is downloaded in September 2020.

Lastly, data was collected at the confluences of Bee Brook and Kirby Brook with the Shepaug River on July 22nd and 23rd. The YSI Probe was used to measure water temperature 10 and 5 feet upriver of the confluence to document the water temperature prior to meeting the stream confluence. Water temperature directly at the confluence, then at 5-foot increments up to 40 feet downriver, was recorded. To account for factors such as depth, sunlight exposure, and current, temperatures were recorded along transects at distances of 1, 2, 4, 8, and 16 feet from the bank at each 5-foot increment. Measuring at such intervals allowed for discerning of the broader thermal refuge area.

Results

Summer mean, July mean, and maximum daily mean water temperatures of the Shepaug River at four sample sites from 2013-2018 overwhelmingly met cool/transitional criteria (Table 1). Water temperature of the Shepaug River was coolest in the upper reach of Hidden Valley and warmest in the lower reach of Steep Rock (Figures 1-3). On average, summer mean water temperature warms roughly 1.65°F from the upper end of Hidden Valley to the lower end of Steep Rock. In 2018, an outlier year, this difference spiked to 2.47°F.

Annual variation of summer mean temperature and July mean temperature was most significant from 2017 to 2018. A gradient in vulnerability to annual temperature change was observed from Hidden Valley to Steep Rock, with Steep Rock experiencing a much greater swing in summer mean temperature and July mean temperature during this time period (3.24°F).

Maximum daily mean water temperatures of the Shepaug River fell between July 5th and August 14th, occurring most often in the month of July.

Site	Preserve	Station	Organization	Year	Water Temperature °C (°F)			Date of Maximum Daily Mean
					Summer Mean	July Mean	Maximum Daily Mean	
Shepaug River (below Bantam River confluence)	Hidden Valley	17413	CTDEEP	2015	20.66 (69.19)	21.57 (70.83)	23.55 (74.39)	7/20
Shepaug River (below Bantam River confluence)	Hidden Valley	17413	CTDEEP	2016	20.87 (69.57)	21.13 (70.03)	25.03 (77.05)	8/14
Shepaug River (below Bantam River confluence)	Hidden Valley	17413	CTDEEP	2017	19.82 (67.68)	20.96 (69.73)	23.34 (74.01)	7/19
Shepaug River (below Bantam River confluence)	Hidden Valley	17413	CTDEEP	2018	21.18 (70.12)	21.85 (71.33)	25.60 (78.08)	8/8
Shepaug River (adjacent Bee Brook confluence)	Hidden Valley	16254	CTDEEP	2014	20.86 (69.55)	21.99 (71.58)	23.06 (73.51)	7/9
Shepaug River (adjacent Bee Brook confluence)	Hidden Valley	16254	CTDEEP	2015	21.03 (69.85)	22.07 (71.73)	24.56 (76.21)	7/20
Shepaug River (adjacent Bee Brook confluence)	Hidden Valley	16254	CTDEEP	2016	21.40 (70.52)	22.03 (71.65)	25.96 (78.73)	8/14
Shepaug River (adjacent Bee Brook confluence)	Hidden Valley	16254	CTDEEP	2017	20.28 (68.50)	21.49 (70.68)	24.23 (75.61)	7/19
Shepaug River (adjacent Bee Brook confluence)	Hidden Valley	16254	CTDEEP	2018	22.05 (71.70)	22.61 (72.70)	25.93 (78.67)	8/8
Shepaug River (Tunnel Road bridge)	Steep Rock	15127	CTDEEP	2013	21.69 (71.02)	24.16 (75.49)	26.15 (79.07)	7/7
Shepaug River (Metcalf Field)	Steep Rock	17412	CTDEEP	2014	20.89 (69.60)	22.00 (71.60)	23.97 (75.15)	7/23
Shepaug River (Metcalf Field)	Steep Rock	17412	CTDEEP	2015	21.56 (70.81)	22.66 (72.79)	25.91 (78.64)	7/20
Shepaug River (Metcalf Field)	Steep Rock	17412	CTDEEP	2017	20.75 (69.35)	21.84 (71.31)	24.98 (76.96)	7/19
Shepaug River (Metcalf Field)	Steep Rock	17412	CTDEEP	2018	22.55 (72.59)	23.64 (74.55)	26.66 (79.99)	7/5

Table 1. Water temperature data from Shepaug River stations. Color code matches DEEP's classification table.

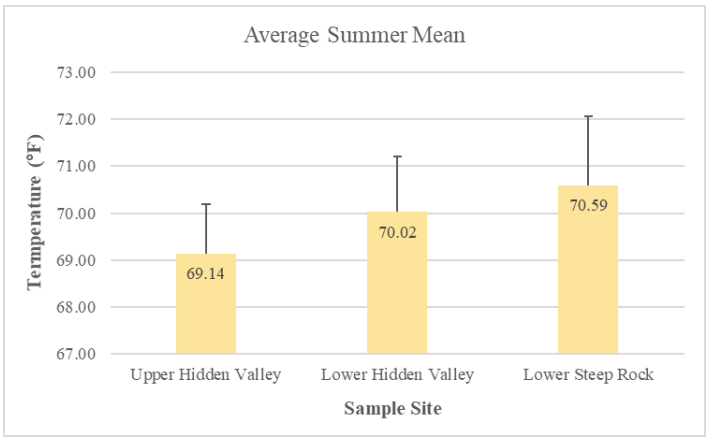

Figure 1. Average summer mean water temperature of the Shepaug River from 2014-2018.

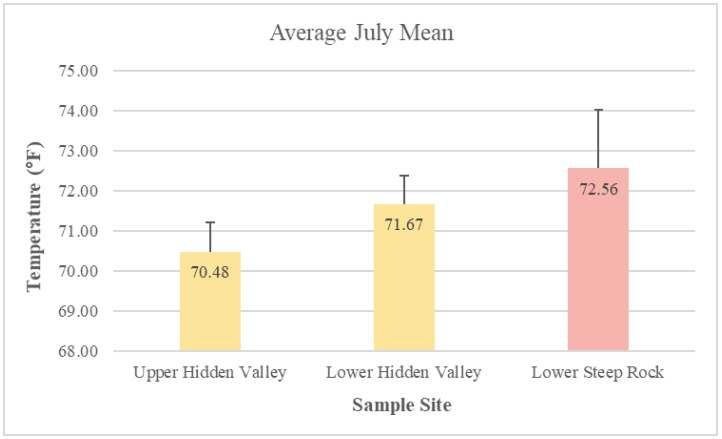

Figure 2. Average July mean water temperature of the Shepaug River from 2014-2018.

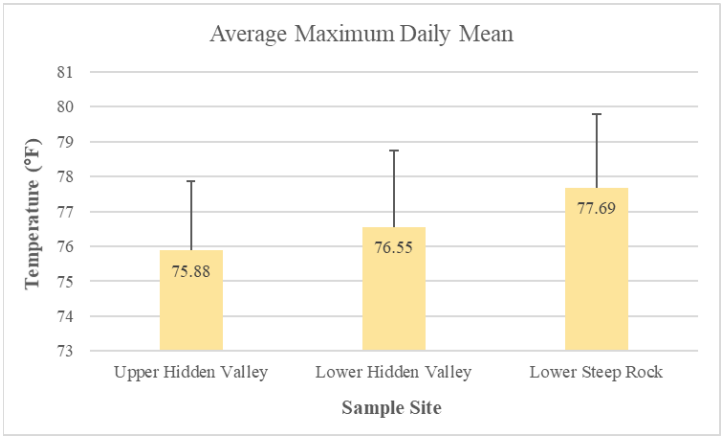

Figure 3. Average maximum daily mean water temperature of the Shepaug River from 2014-2018.

Bee Brook, Kirby Brook, and Curtis Brook all met one or more criteria to be classified as cold water, except for Bee Brook in 2012, which registered as cool/transitional. Curtis Brook is the only stream that met all cold water criteria (Table 2).

Site	Preserve	Station	Organization	Year	Water Temperature °C (°F)			Date of Maximum Daily Mean
					Summer Mean	July Mean	Maximum Daily Mean	
Bee Brook (from mouth to footbridge)	Hidden Valley	15519	CTDEEP	2010	19.11 (66.40)	20.16 (68.29)	21.68 (71.02)	6/28
Bee Brook (from mouth to footbridge)	Hidden Valley	15519	CTDEEP	2012	19.32 (66.78)	20.27 (68.49)	22.81 (73.06)	8/5
Kirby Brook	Steep Rock	15128	HVA	2019	17.38 (63.28)	18.73 (65.71)	23.28 (73.90)	7/21
Curtis Brook	Steep Rock	20096	HVA	2019	16.64 (61.95)	18.04 (64.47)	21.56 (70.81)	7/21

Table 2. Water temperature data from Shepaug River tributary stations. Color code matches DEEP's classification table.

Tables 3 and 4 display confluence temperatures in a range of red to blue, with blue representing the coolest relative temperatures and red representing the warmest. Cell sizes are relative to the distance between measurements. By using this format, one can gauge the thermal refuge area. Data shows Bee Brook having a more significant and widespread influence on water temperature within the mainstem than Kirby Brook.

BEE BROOK		Distance from Water Edge (feet)				
		1	2	4	8	16
Distance from Confluence (feet)	10	76.10	76.14	76.18	76.34	76.56
	5	76.54	76.25	76.30	76.38	76.54
	0	70.83	71.49	75.50	76.42	76.74
	-5	71.03	70.86	70.91	74.40	76.83
	-10	70.92	70.91	71.11	76.56	76.91
	-15	71.52	71.25	73.66	76.95	77.17
	-20	71.48	72.03	75.58	76.98	77.16
	-25	71.50	72.22	75.92	77.13	77.43
	-30	72.39	72.38	75.68	77.20	77.66
	-35	75.00	74.70	74.15	76.74	77.75
	-40	76.58	76.58	76.61	76.42	77.70

Table 3. Water temperature (°F) at Bee Brook and Shepaug River confluence.

KIRBY BROOK		Distance from Water Edge (feet)				
		1	2	4	8	16
Distance from Confluence (feet)	10	73.82	73.86	74.02	74.10	74.32
	5	73.70	73.89	74.10	74.21	74.42
	0	66.78	69.66	74.54	74.78	74.85
	-5	70.65	72.20	75.67	74.82	74.91
	-10	69.71	72.30	73.74	74.92	75.02
	-15	66.76	69.52	73.01	74.86	75.02
	-20	68.74	67.42	71.76	75.05	75.01
	-25	67.92	67.49	70.90	73.95	75.22
	-30	68.82	70.89	72.38	74.25	75.34
	-35	70.63	72.82	73.21	74.37	75.53
	-40	70.92	72.14	73.17	74.33	75.77

Table 4. Water temperature (°F) at Kirby Brook and Shepaug River confluence.

Discussion

This research has documented the Shepaug River as a cool transitional lotic system based on DEEP classification. On average, the summer mean of the river fell between 69 and 71 degrees, quite far from the 65 degrees needed to classify the Shepaug as cold. Rather, in almost all instances, the temperature was closer to or exceeded the 71°F mark classifying the Shepaug as warm. In 2018, over half of the criteria at two different sites met warm classification.

As predicted, water temperature of the Shepaug River warmed with downstream progression. Hovering around the 70°F mark, a threshold where stress of cold water fish species increases exponentially, even just a few degree difference in water temperature is significant. Protection of thermal refuges is critical throughout the Shepaug River system; however, this difference over the course of river suggests that thermal refuge protection and enhancement should be prioritized in downstream reaches within SRA's holdings.

Furthermore, investigations into Kirby Brook, the largest tributary of the Shepaug River in Steep Rock, found that it provides a small area of thermal refuge within the mainstem. Thus, it may be prudent to prioritize enhancement of this thermal refuge over other streams. This recommendation aligns with current efforts to remove the passage barrier presented by the culvert under Tunnel Road on Kirby Brook. Recommended strategies for improved refuge include centralization of discharge into one main channel as opposed to several small divisions during low flow conditions and creating a deflector in the mainstem that prohibits warm river water from quickly diffusing with the cooler stream water. Installation of woody debris at these thermal refuges may slow the warming of water through shading and simultaneously provide cover for fish seeking refuge. It is clear that the conditions provided by Bee Brook and Kirby Brook are essential for cold water fish inhabiting the cool/transitional Shepaug River. Every effort should be made to promote their status as cold water systems.

The same applies to the Shepaug River and the threat of it evolving into a warm water system, which hold less conservation value in the face of climate change. Preservation of unprotected, forested property within the Shepaug River watershed will be paramount in combating a warming trend. SRA should continue its investment in the oversight of the City of Waterbury's water management of the Shepaug River reservoirs and instigate efforts to improve reservoir dam function. Increasing the amount of discharged water during summer months and further alteration of the design from a top to bottom release would result in incredible improvement to the health and quality of the Shepaug River.