Temperature Regime Characteristics of High-Quality Coldwater Streams in New England

MA Division of Fish and Wildlife
Temperature Characteristics of Coldwater Fish Habitat

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B. PROJECT RESULTS

B.1 Temperature Characteristics of Coldwater Fish Habitat

Overview*:* As part of the Temperature Regime Characteristics of High-Quality Coldwater Streams in New England project, a subset of the dataset was analyzed to determine the characteristics of streams having coldwater fish habitat. The Massachusetts Division of Fisheries and Wildlife (MDFW) and the Connecticut Department of Energy and Environmental Protection (DEEP) identified a number of streams supporting coldwater fish habitat where coldwater stream are those streams with a validated presence of established native populations of *Cottus cognatus* (slimy sculpin) and/or *Salvelinus fontinalis* (eastern brook trout). These agencies deployed water temperature probes to develop stream temperature observations to characterize coldwater fish habitat streams. This dataset differs from the broader dataset because the broader datasets includes sites in which stream temperature was monitored for many different reasons. Additionally, the fishery data, used to classify the streams, may not have been collected coincident with the temperature data.

The MDFW streams were determined by reviewing percent forested watershed, number of road crossing, and existence of wells or point discharges. From a fish community standpoint, the criteria for each site changed by watershed in order to some 'least impacted' sites throughout the state, but the goal was to have at least 50% of the fish community be coldwater individuals (if you capture 100 fish, at least 50 would be coldwater fish). In general, the selection criteria was: greater than 80% forested, greater than 50% coldwater individuals, no wells, discharges, and relatively few road crossings. The desktop selection process obtained temperature information at some good habitat with one sample on each stream that has greater than 50% coldwater individuals. The sites were not ground truthed to see if there might have been some very site-specific impacts. The MDFW dataset is a multiple year dataset that includes continuous annual measurements. Sampling began in July 2005 and continued through October 2007. A total of 37 sites were sampled. Of these initial sites, eight sites only have data through October 2005 because the thermographs were lost over the winter. An additional ten sites had missing data during some portion of the long-term record. Summary statistics could be calculated for all months.

CTDEEP's Bureau of Water Protection and Land Reuse (WPLR) identified 11 coldwater habitat site locations using previously collected fish community samples and selected sites from over 500 temperature monitoring locations. Selected sites had established populations of slimy sculpin (greater than 5 individuals in a sample reach). No viable sites were located in southwestern Connecticut. These sites were monitored for water temperature water temperature probes during April to September 2010. These same locations were electrofished during the summer 2010 to validate the presence of established populations of slimy sculpin and/or eastern brook trout. The CT DEEP has continued to monitor the sites annually and additional observations and findings are summarized in Beauchene (2010, 2011). Sites are shown in Figure B.1.1 below and listed in Appendix B.1 at the end of this document.

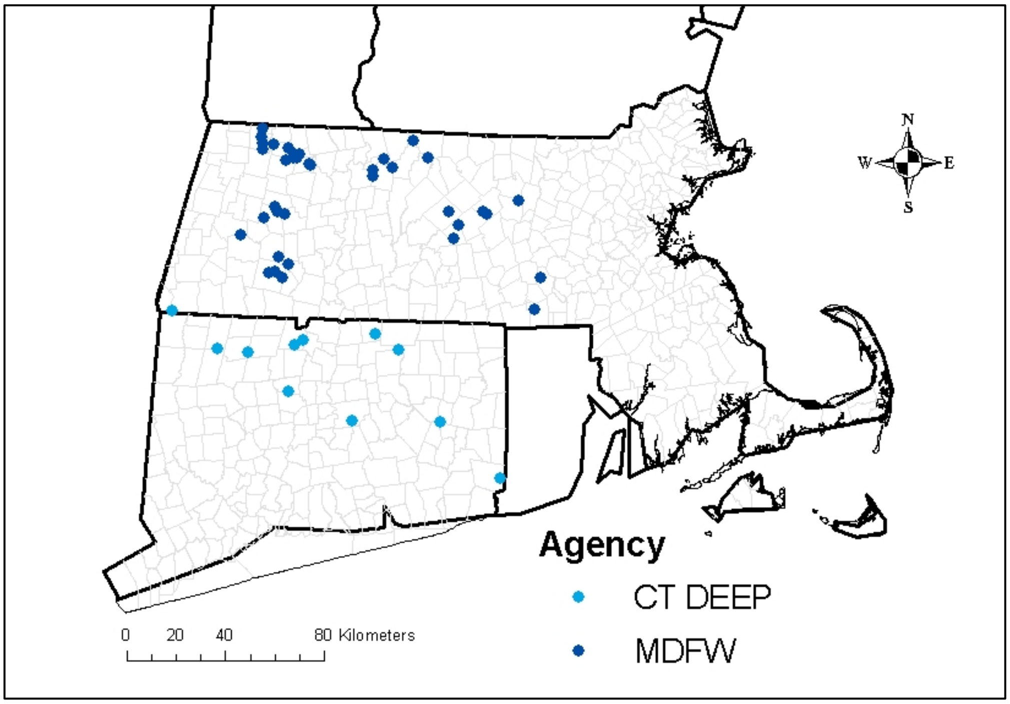


Figure B.1.1 Location of coldwater fish habitat streams by agency.

In addition, many of the state agencies are interested in classifying streams based on summer temperatures. Proper stream classification is vital to accurately measure the health of a stream and its inhabiting species. If misclassified, a stream could be held to an inadequate measure of its biological integrity, and thus proper care may not be given to ensuring the health of the stream and the species which inhabit the ecosystem. Mike Beauchene of CT DEEP suggested that it is better to use temperatures to determine stream thermal regimes rather than the presence of fish species. Lyons et al.'s (2009) developed a framework for predicting thermal regimes (cold, cold transitional, warm transitional, and warm water) based on stream temperature. For Michigan and Wisconsin, they identified stream temperature statistics and provided quantitative values of those statistics for streams' thermal regimes classification (Table B.1.1). The MDFW and CT DEEP stream temperature values are considered in light Lyon et al.'s cold stream temperature temperatures.

Table B.1.1: Lyons Thermal Regime Classifications

Class and Subclass	**June – August Mean (° C)**	**July Mean (°C)**	**Maximum Daily Mean (°C)**
Cold Water	< 17.0	< 17.5	< 20.7
Cool Water	17.0 – 20.5	17.5 – 21.0	20.7 – 24.6
Warm Water	> 20.5	> 21.0	> 24.6

***Methods**:* This report summarizes a variety of stream temperature characteristics by agency. Agency results are not combined because they represent difference sampling periods. For each day, the mean, minimum, maximum and range (maximum minus minimum) were computed. Statistics were summarized on a monthly basis by site and then the distribution of values across all sites was determined. Analysis values appear in Tables in Appendix B.1.

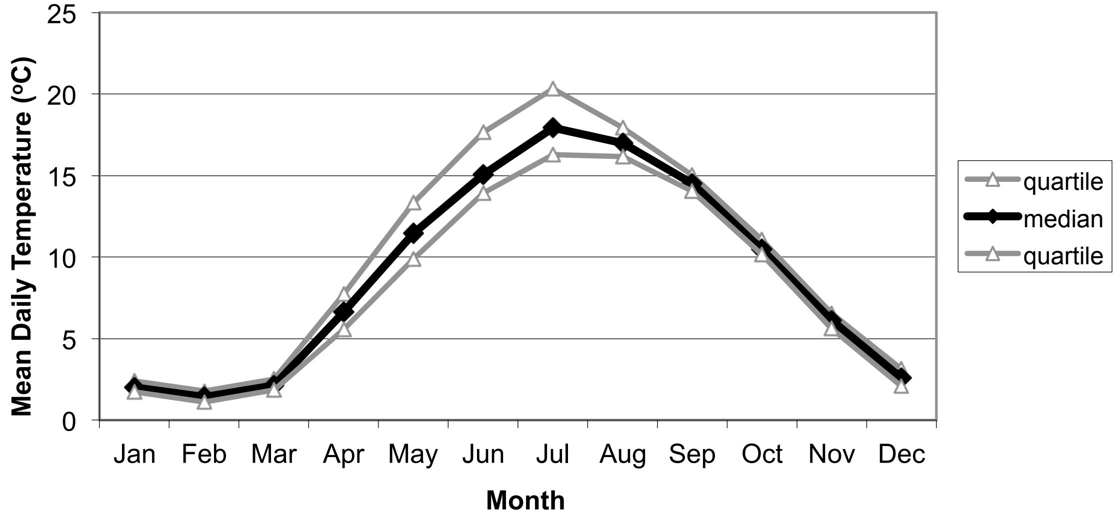
Results

Mean Temperature: Daily mean values provide an overall look at typical temperatures in streams. Temperatures can be expected to vary day to day. Thus, when the daily values are averaged over the course of a month, the seasonal evolution of the stream's temperature becomes more evident. Examining the variability or standard deviation of daily values within a month provides a measure of temperature consistency and its evolution seasonally.

Daily mean temperatures were typically warmest in July with cooler temperatures by approximately $1^{o}C$ in August (Figure B.1.2). Median July values were 17.9 and $19.3^{o}C$ for the MDFW and CT DEEP values, respectively. Temperature values were quite consistent across sites from September to March with the interquartile range was typically less than $1^{o}C$. The upper quartile values are 14.0, 10.2, 5.9, 2.4, 2.0, 1.4, $1.7^{o}C$ for September to March, respectively. There was much more variability across sites during June and July with the interquartile range on the order of $4^{o}C$ for July. Temperature trends and values were fairly consistent across the two agency's datasets.

The typical site had the lowest day-to-day variability (over the course of a month) during the winter (Figure B.1.3). Elevated variability occurred during the spring and fall as the streams warmed and cooled, respectively. Despite the higher temperature, stream temperature variability was damped during the summer. The lowest summer day-to-day variability occurred in July for MDFW and August for CT DEEP with typical values on the order of $1.5^{o}C$. Temperature variability values were fairly consistent across the two agency's datasets.

For each site, the warmest and the coolest day of each month were identified at each site. Temperatures for those dates were compiled across sites (Figures B.1.4 and 5). Winter months consistently had stream temperatures near freezing for November to February, but also routinely had values that were much warmer during those months. February was the coldest month with 75% of the streams never exceeding temperatures of $3.5^{o}C$. Daily minimums increased throughout the summer. The warmest minimum temperature occurred in July for MDFW and August for CT DEEP. The warmest day's temperature occurred in July for both MDFW and CT DEEP, but these values were quite similar to the August values.



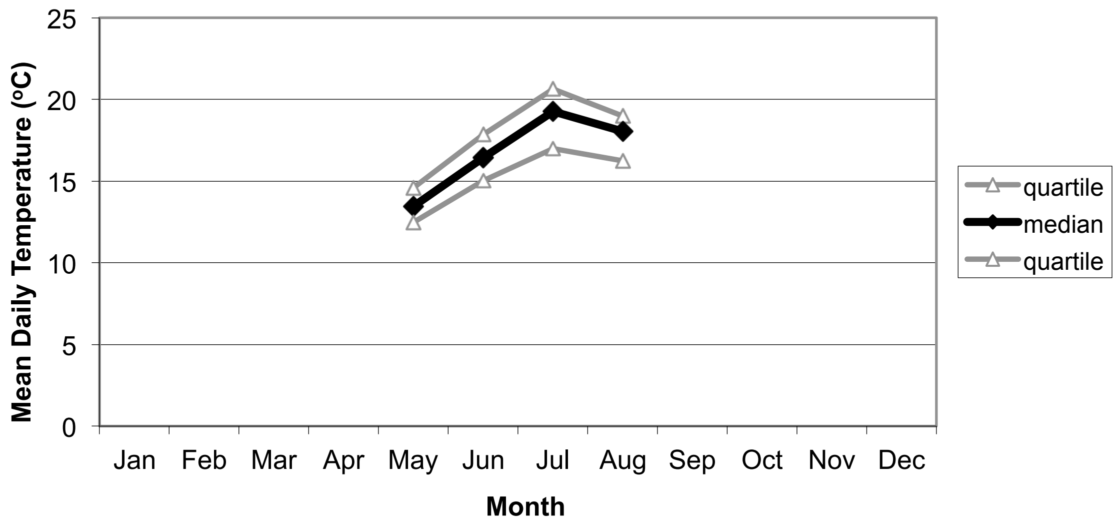
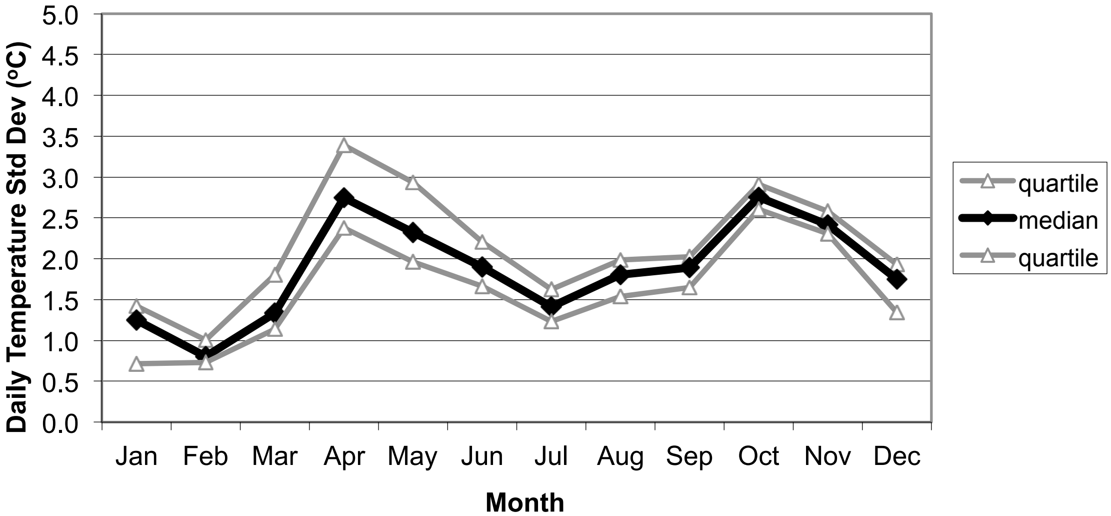


Figure B.1.2. MDFW (upper) and CT DEEP (lower) upper quartile, median, and lower quartile values of monthly mean values summarized across sites. The mean monthly value was calculated by site, and then quartiles were determined based on all sites. Only sites having 15 or more days in a given month were used.



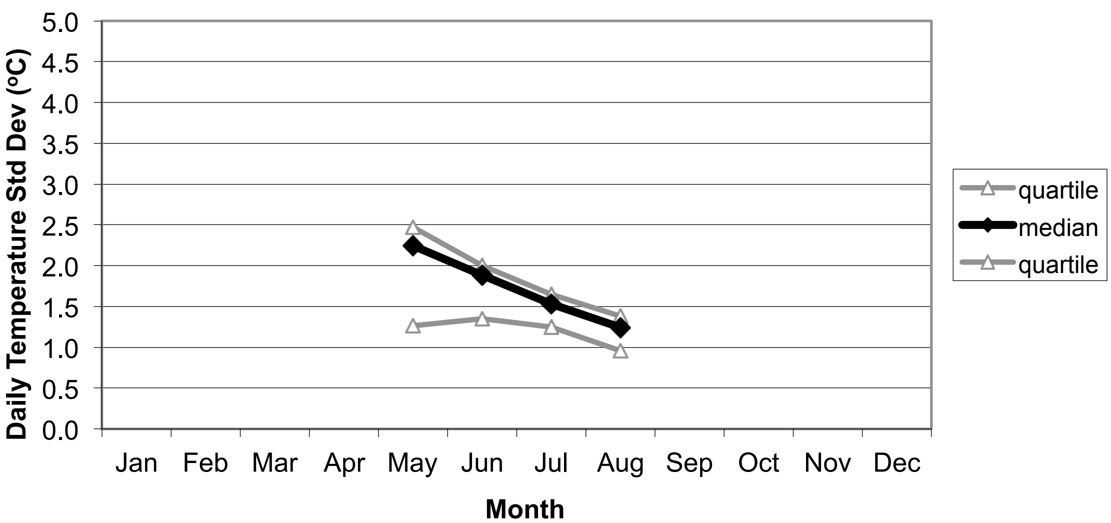
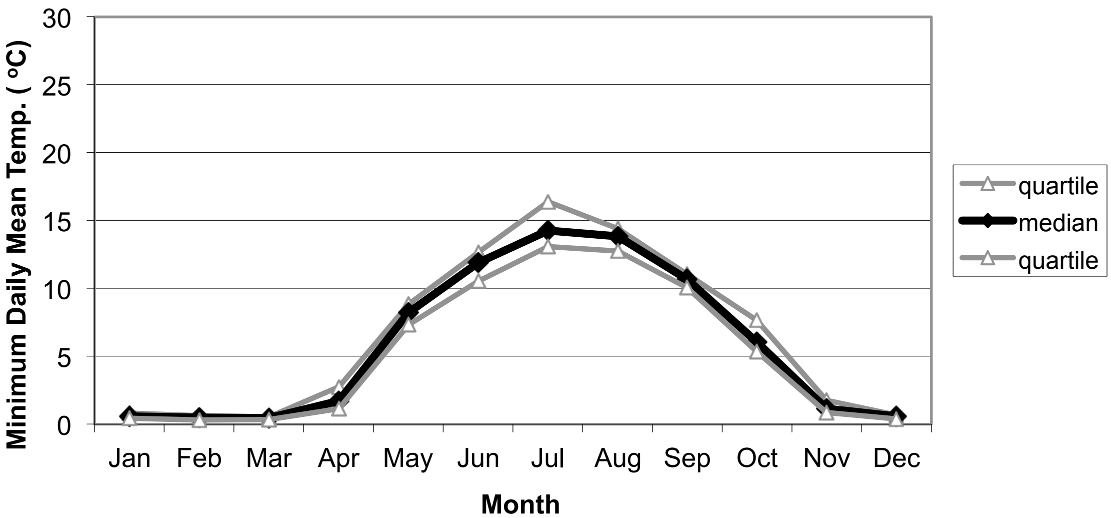


Figure B.1.3. MDFW (upper) and CT DEEP (lower) upper quartile, median, and lower quartile values of the standard deviation of the mean values summarized across sites. The standard deviation was calculated from daily values for each site and, and then quartiles were determined based on all sites. Only sites having 15 or more days in a given month were used.



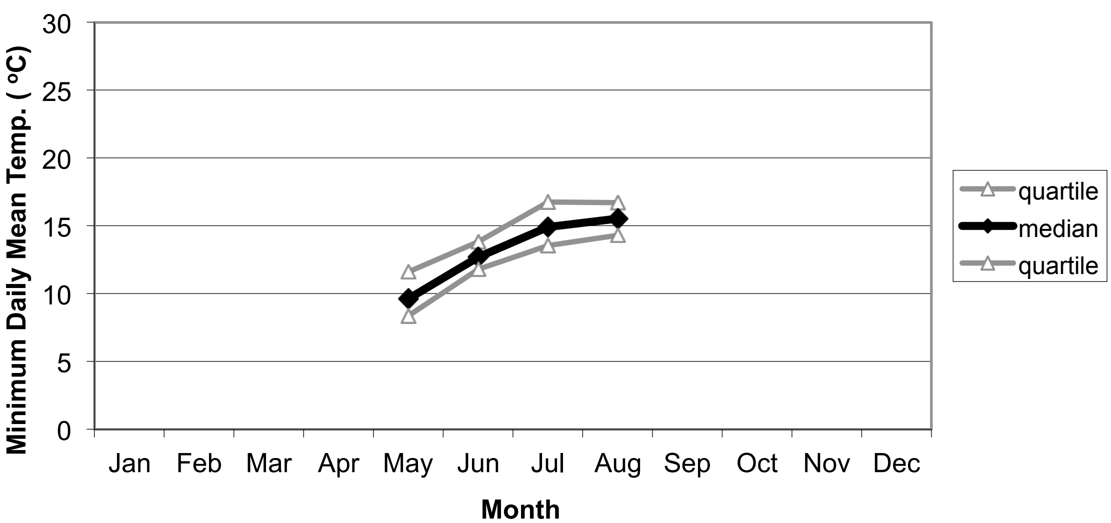
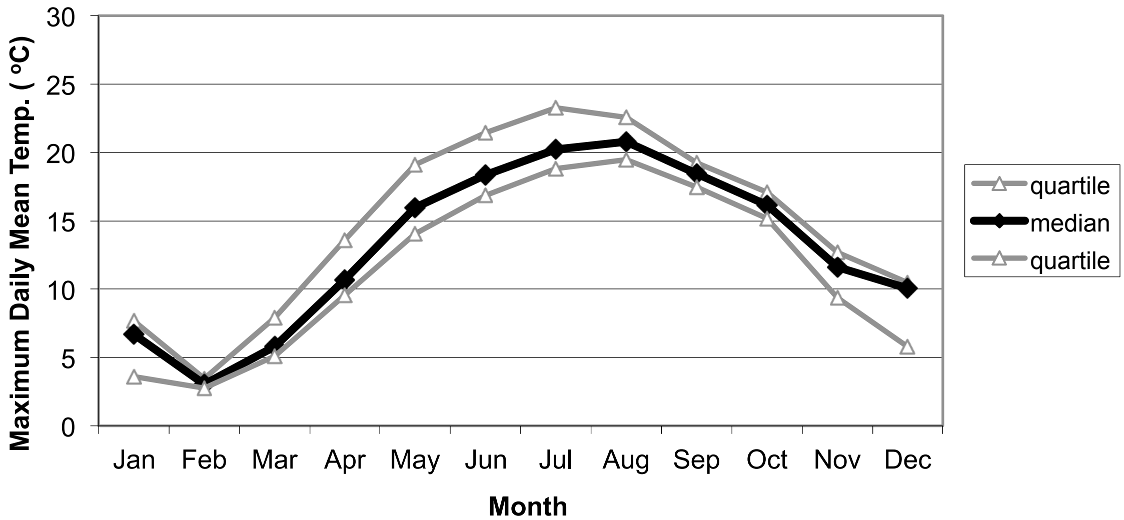


Figure B.1.4. MDFW (upper) and CT DEEP (lower) upper quartile, median, and lower quartile values of the coolest average daily temperature each month summarized across sites. The minimums, the lowest daily value for each site, were identified, and then quartiles were determined based on all sites. Only sites having 15 or more days in a given month were used.



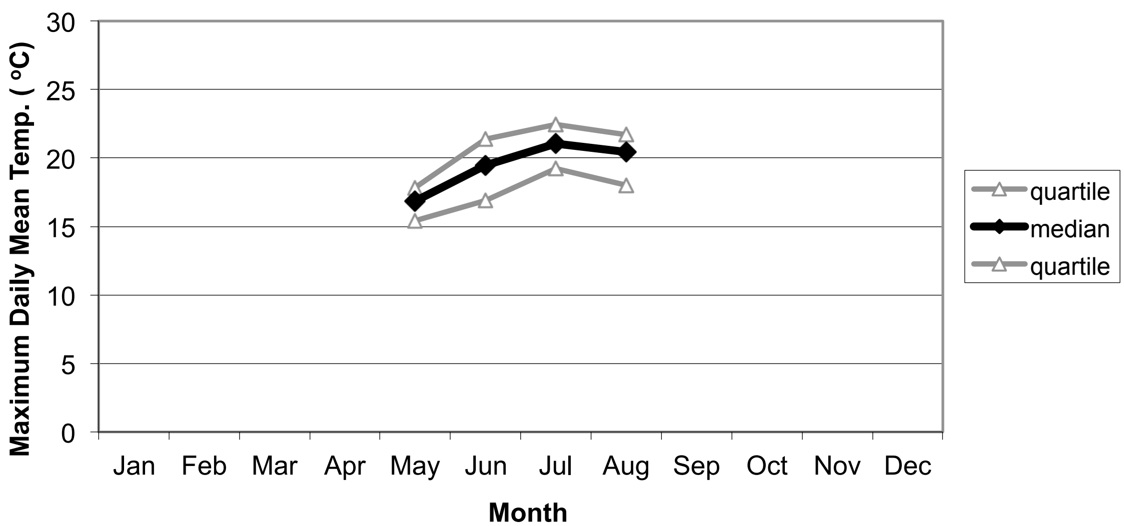
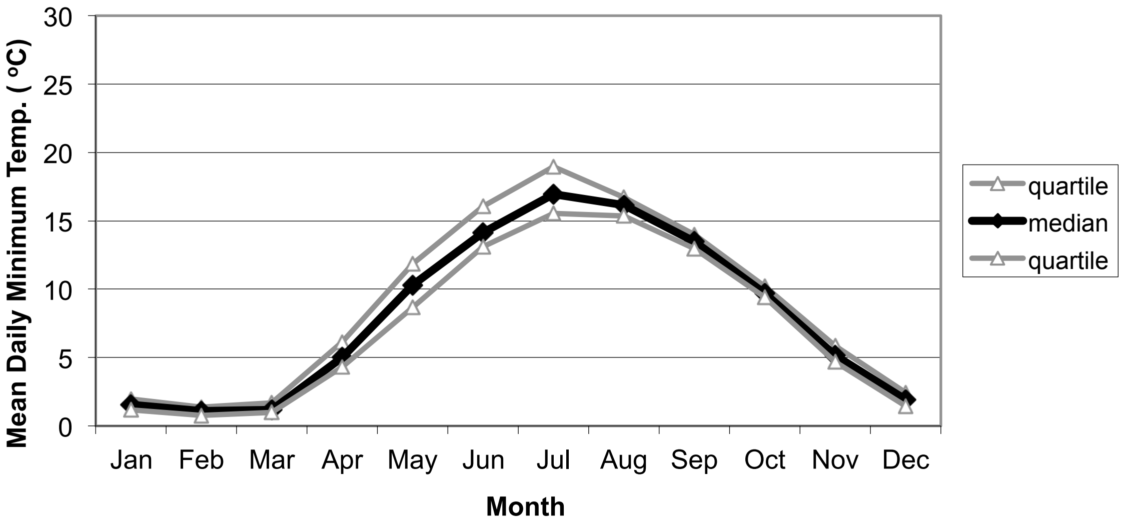


Figure B.1.5. MDFW (upper) and CT DEEP (lower) upper quartile, median, and lower quartile values of the warmest average daily temperature each month summarized across sites. The maximums, the highest daily value for each site, were identified, and then quartiles were determined based on all sites. Only sites having 15 or more days in a given month were used.

Daily Temperature Minimums and Maximums: While stream temperature data are often summarized daily, monthly and seasonally, there is value in understanding the range of temperatures within a day. Extreme temperatures, even for a relatively short period, may be lethal to some biota. Similarly, if stream temperatures cool adequately during hot periods, then some relief may be provided to stressed biota. The following section presents data that summarize typical maximum and minimum temperatures over the course of a day. The range of those values is also considered.

The typical lowest (Figure B.1.6) and highest temperatures (Figure B.1.7) each day were extremely consistent across these coldwater fish habitat sites from Fall into early Spring. The interquartile range was less than one degree. From April to September, there was more variation among sites. During the warmest months, the typical (median) MDFW stream cooled on average to 16.9 and 16.2^{o}C in July and August, respectively. The CT DEEP stream did not cool as much; 18.0 and 16.9^{o}C in July and August, respectively. During the warmest months, the typical (median) stream temperature at the hottest point during the day was 19.1 and 17.9^{o}C in July and August, respectively, for MAFW. The CT DEEP streams were warmer still; 20.8 and 19.0^{o}C in July and August, respectively. These values are about 1^{o}C warmer than the daily averages values. There is considerable range in these daily maximum and minimum across sites.

The stream temperature has the greatest daily temperature range in April and May, on the order of 3^{o}C (Figure B.1.8). After its peak in April, the temperature range decreases until February. During summer months, stream temperatures typically vary by about 2^{o}C each day. These values vary by site with some sites having considerably more daily variation. The MDFW and CT DEEP temperature ranges are quite similar except for the anomalously low variability in June 2010 for the CT DEEP sites.



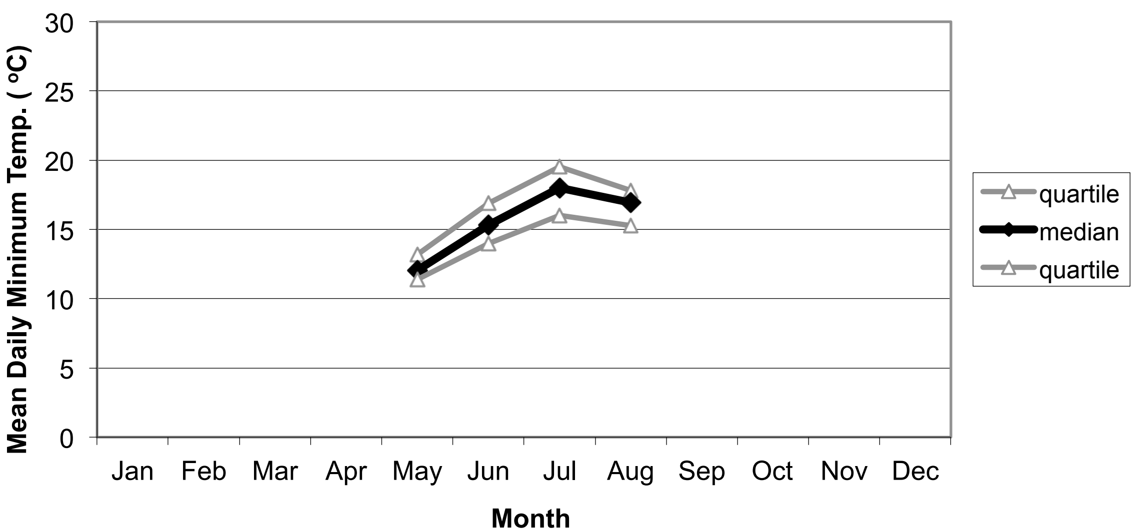
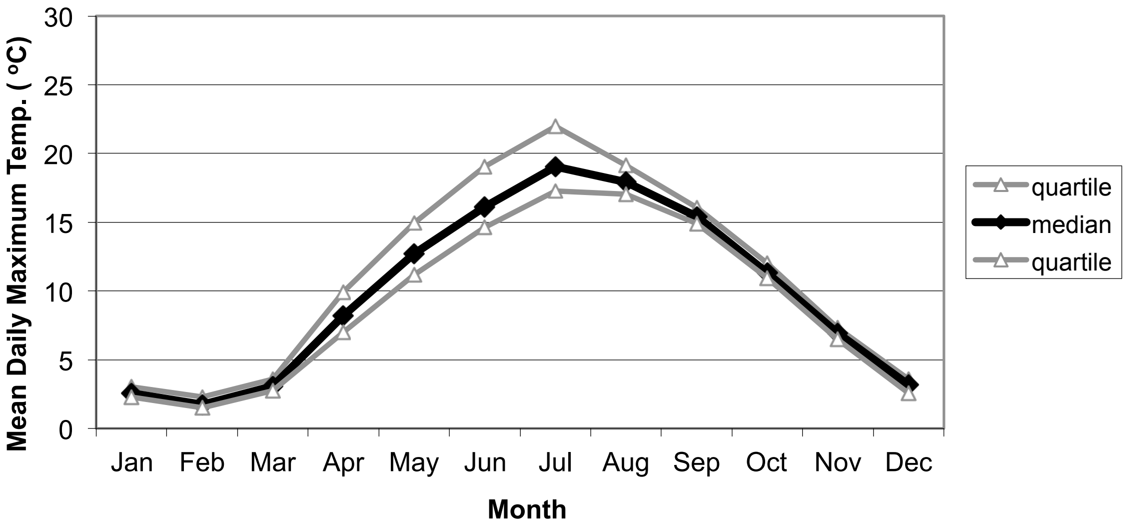


Figure B.1.6. MDFW (upper) and CT DEEP (lower) upper quartile, median, and lower quartile values of the daily minimum each month summarized across sites. The daily minimums, the coolest temperature each day at a site, were identified and averaged over the month, and then quartiles were determined based on all sites. Only sites having 15 or more days in a given month were used.



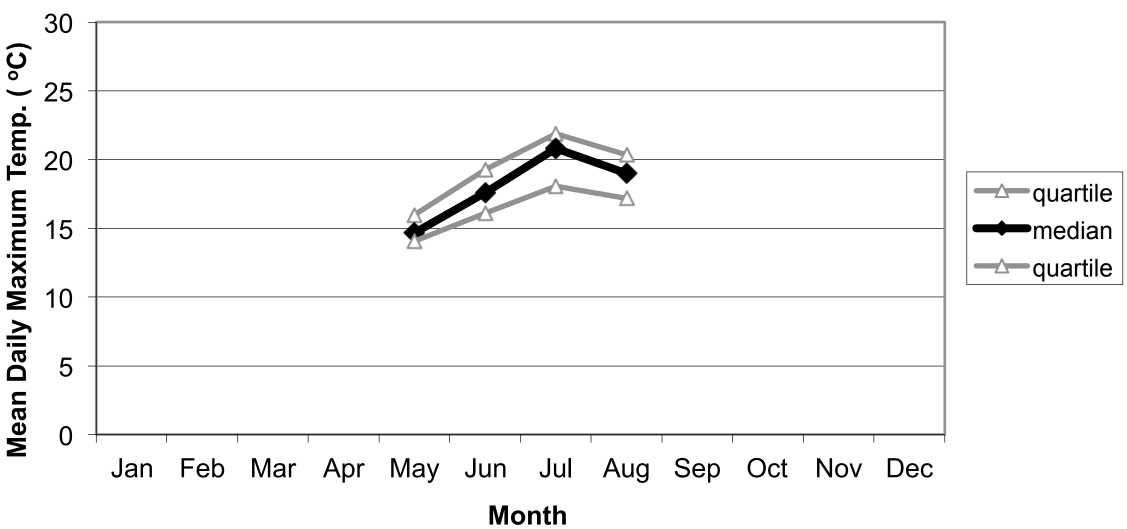
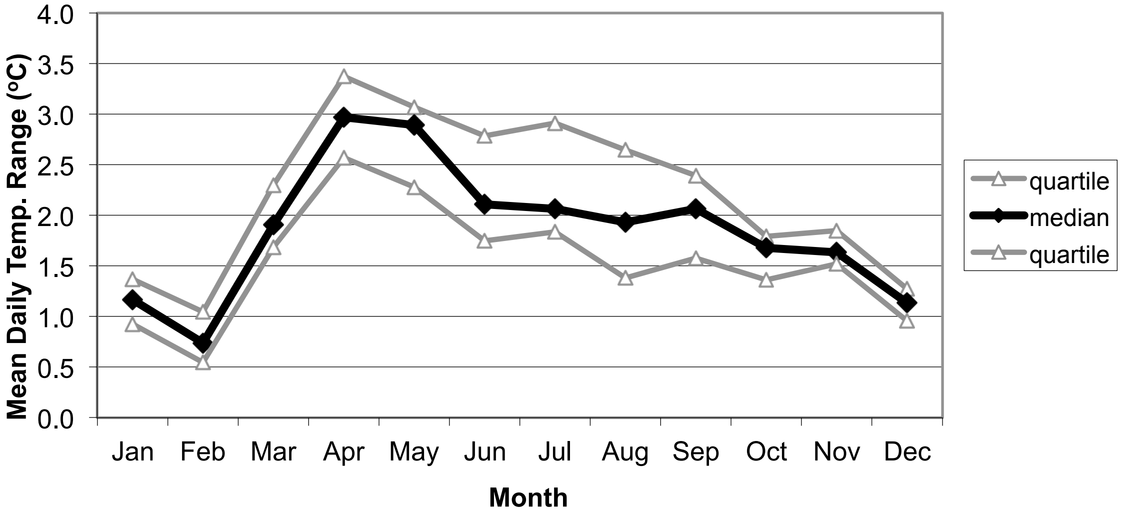


Figure B.1.7. MDFW (upper) and CT DEEP (lower) upper quartile, median, and lower quartile values of the daily maximum each month summarized across sites. The daily maximums, the warmest temperature each day at a site, were identified and averaged over the month, and then quartiles were determined based on all sites. Only sites having 15 or more days in a given month were used.



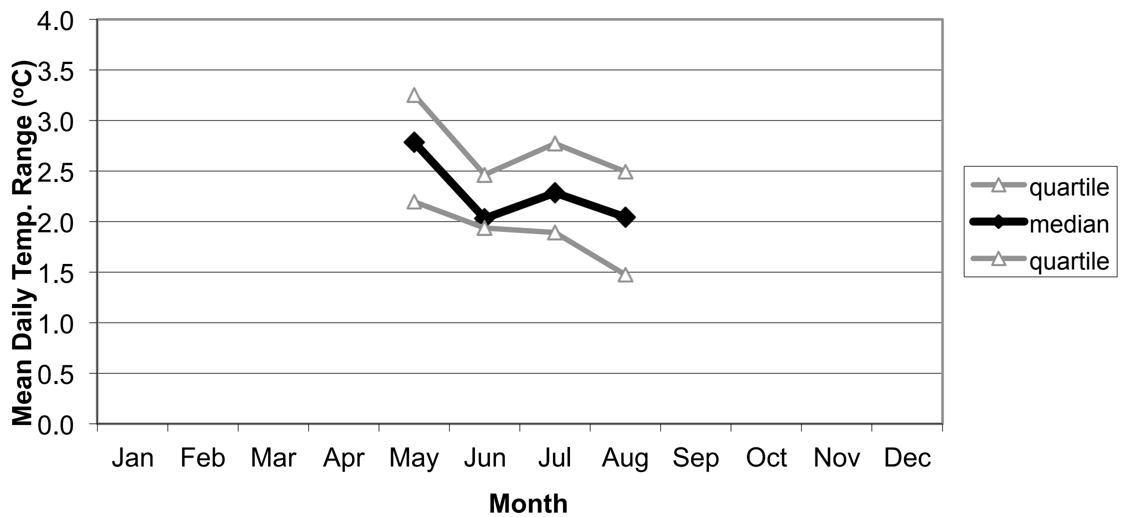


Figure B.1.8. MDFW (upper) and CT DEEP (lower) upper quartile, median, and lower quartile values of the daily temperature range for each month summarized across sites. The daily ranges, the difference between the warmest and coolest temperatures each day at a site, were identified and averaged over the month, and then quartiles were determined based on all sites. Only sites having 15 or more days in a given month were used.

Daily Temperature Thresholds: Although the average July temperature values were 17.9 and 19.3°C for the MDFW and CT DEEP values, respectively, over a summer, stream temperatures will warm above these temperatures. The magnitude and the persistence of warm temperatures will likely combine to impact stream biota. Figure B.1.9 shows the likelihood of observing temperature values above critical temperatures at coldwater fish habitat streams and the average duration for which those temperatures persist. It is relatively common to observe temperatures above 18 and 19°C. Temperatures above 19°C typically persist for less than one week. Approximately 50% of the sites had temperatures that exceeded 20°C. At most sites, these temperatures last for less than five days. However, several sites had temperatures that exceeded 20°C for more than two weeks. Relatively few sites had temperatures that exceeded 21°C and these elevated temperatures occurred for relatively short durations. It was extremely unusual to find a site with temperatures above 23°C in this dataset.

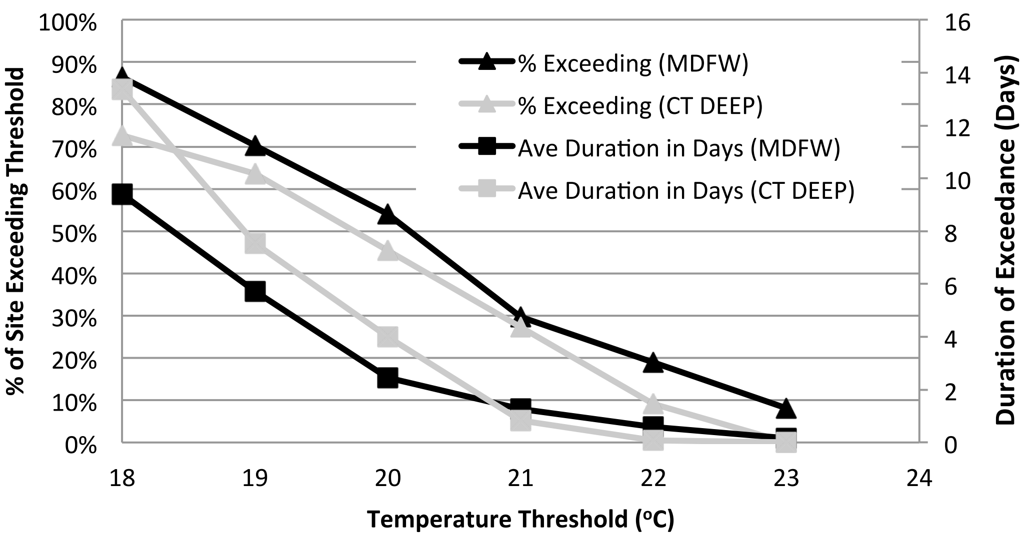
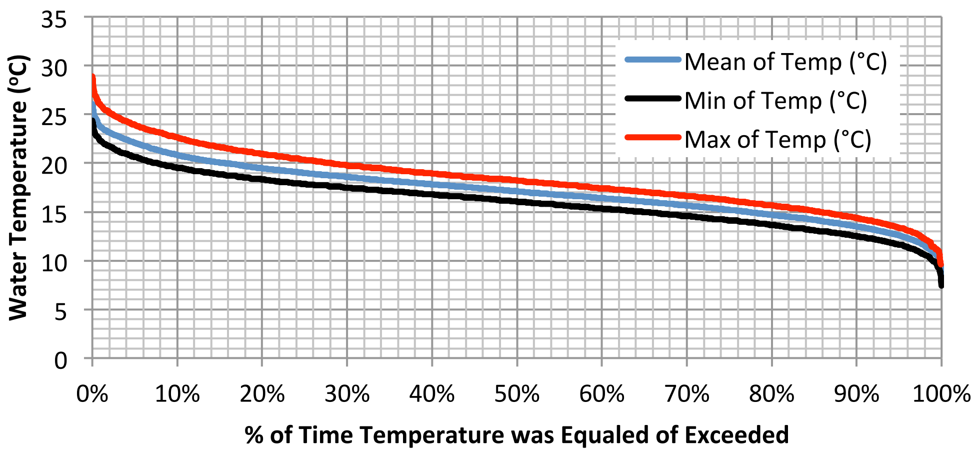


Figure B.1.9. Percentage of sites exceeding daily temperature threshold by minimum temperature and the average duration of exceedance for MDFW and CT DEEP sites.

Temperature duration curves: As used and described by Beauchene (2010, 2011), temperature duration curves show the percent of time a given temperature was equaled or exceeded. These plots have value because they can concisely summarize very large data sets in a single plot. The plots are created by rank ordering the temperatures from warmest to coolest for all summer days across sites. Each observation is then assigned an exceedance probability (the probability that a given temperature is likely to be exceeded on a daily basis).

The water temperature data for June, July and August from the MDFW 3-yr dataset and the CT DEEP 2010 are presented as a temperature duration curve in Figure B.1.10. The upper line represents the average daily maximum, the middle line the daily mean temperatures and the lower line the daily minimum temperatures for all stations. This plot can be used to estimate the likelihood that a summer stream temperature is equal to or cooler than a particular value. For example 50% of the average daily mean temperatures equal to or cooler than 17.1 or 17.6°C for MDFW and CT DEEP, respectively. Quantiles of the temperature duration curves are summarized in Table B.1.2.



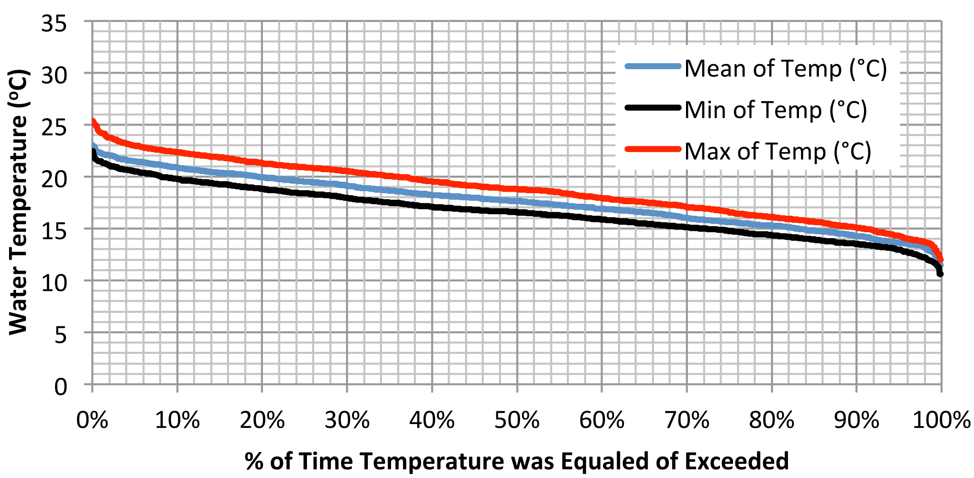


Figure B.1.10. Temperature duration curves for MDFW (upper) and CT DEEP (lower) sites developed from daily stream temperature observations for June, July, and August.

Table B.1.2. Summary temperature exceedance values from temperature duration curves for MDFW and CT DEEP based on daily temperature averages, minimums, and maximums for June, July, and August.

Quantiles		MAFW Mean (°C)	MAFW Min (°C)	MAFW Max (°C)	CT DEEP Mean (°C)	CT DEEP Min (°C)	CT DEEP Max (°C)	MA & CT Mean (°C)	MA & CT Min (°C)	MA & CT Max (°C)
100.0%	maximum	26.0	24.4	28.9	23.0	22.5	25.4	26.0	24.4	28.9
99.5%		24.5	22.8	26.6	22.4	21.6	24.9	24.3	22.7	26.4
97.5%		22.9	21.5	24.9	22.0	21.0	23.6	22.8	21.3	24.8
90.0%		20.8	19.5	22.6	20.9	19.8	22.3	20.9	19.6	22.5
75.0%	quartile	19.0	17.9	20.3	19.5	18.4	20.9	19.1	17.9	20.5
50.0%	median	17.1	16.0	18.2	17.6	16.6	18.8	17.2	16.2	18.3
25.0%	quartile	15.2	14.1	16.2	15.6	14.7	16.6	15.3	14.3	16.3
10.0%		13.5	12.5	14.4	14.3	13.5	15.1	13.6	12.7	14.5
2.5%		11.8	10.8	12.5	13.4	12.3	13.8	12.0	11.0	12.7
0.5%		10.5	9.5	11.1	12.0	11.4	12.7	10.6	9.6	11.2
0.0%	minimum	8.6	7.4	9.6	11.5	10.6	12.0	8.6	7.4	9.6

Lyons et al. Temperature Categories

The MDFW and CT DEEP stream temperature values were used to calculate Lyon et al.'s stream temperature statistics: June to Aug mean temperature, July mean temperature and maximum daily mean temperature. Table B.1.3 summarizes the findings for all sites, which had adequate observations to calculate all three statistics. Overall, it appears that the Lyons et al. temperatures are too low to be used to classify streams as "cold" for the MDFW and CT DEEP streams. Only 30% of the streams, nine of the 27 MDFW streams and three of the ten CT DEEP streams, met all three of the Lyons et al. criteria. The three criteria also appear to be somewhat redundant for these streams. If one criterion was satisfied, it was highly likely all criteria were satisfied. The June – August mean value appears to be the least restrictive.

Using the Lyon et al.'s thermal regime classification statistics, the MDFW and CT DEEP datasets can be used to estimate alternate values for this region. For the 37 study sites, the upper quartile of temperature values are 19.1, 20.5, and 23.0ºC for the June – August mean, July mean, and maximum daily mean. These temperature values might be considered as potential thresholds for identifying coldwater streams in this region. However, this threshold would cause 25% of these coldwater fish habitat streams to not be identified as a coldwater regime. A less restrictive threshold might be reasonable. If 90% of the sites had temperature values less than 19.3, 20.9, and 24.6ºC for the June – August Mean, July mean, and maximum daily mean. In summary, Lyon et al.'s thermal regime classification values are too low for this region's streams. If their statistics were to be used for the New England region, the threshold values would need to be increased by 2 to 3^{o}C.

Table B.1.3. Summary temperature statistics based on Lyons et al.'s thermal regime classification for MDFW and CT DEEP based on daily temperature averages. Green highlight indicates that Lyons et al.'s coldwater criterion is satisfied.

Site ID	Count	June – August Mean (º C)	July Mean (ºC)	Maximum Daily Mean (ºC)
Lyons Criteria		< 17.0	< 17.5	< 20.7
MA Bron55	133	15.7	16.8	19.6
MA Cold55	197	15.3	16.3	19.6
MA Dunb55	111	14.7	14.8	19.8
MA Fife55	203	13.0	13.6	17.4
MA Firs55	118	16.1	16.2	20.2
MA Gibb55	126	15.6	16.3	19.7
MA Kear55	225	15.1	15.6	19.9
MA Maxw55	69	14.6	15.7	18.8
MA UntM55	224	16.2	17.0	20.3
MA HogH55	210	16.4	17.4	21.7
MA Stag55	218	16.1	16.8	21.1
MA Tiff55	126	16.1	17.3	20.8
MA Clak55	110	16.6	18.1	22.0
MA Gulf55	226	16.8	18.0	21.4
MA Roar55	218	16.8	17.6	21.7
MA Whet55	224	17.0	17.8	21.5
MA Cobb55	197	19.9	21.7	25.9
MA Coll55	226	18.5	19.6	23.9
MA Lyon55	224	20.4	22.3	26.0
MA Mayn55	197	19.5	21.0	24.9
MA Park55	197	19.2	20.8	23.9
MA Pleas55	197	19.1	20.3	23.5
MA Roar60	225	19.2	20.6	24.5
MA SWac55	184	17.3	18.6	22.1
MA Towe55	126	17.4	18.9	21.8
MA Warr55	197	17.6	18.7	23.2
MA Weke55	105	19.2	20.9	23.6
MA Upper Quartile		18.8	20.0	23.5
CT_1440	92	15.5	16.4	18.0
CT_1456	92	16.2	17.2	19.6
CT_1916	92	14.5	15.0	16.7
CT_717	92	17.4	18.8	20.7
CT_1083	92	19.2	20.7	22.8
CT_2394	92	17.7	19.0	20.9
CT_2515	92	18.2	19.6	21.2
CT_359	92	19.1	20.5	22.3
CT_480	92	19.2	20.6	23.0
CT_606	92	19.3	20.7	22.3
CT Upper Quartile		19.2	20.6	22.3
Combined CT and MA Upper Quartile		19.1	20.5	23.0
Combined CT and MA Upper 90 %		19.3	20.9	24.6

References

Beauchene, M. 2010. CT DEEP Characterization of Water Temperature in Cold Water Fish Habitat: Project Status Report Year 1 of 5, Summer-2010.

Beauchene, M. 2011. CT DEEP Characterization of Water Temperature in Cold Water Fish Habitat: Project Status Report Year 2 of 5, Summer-2010.

Lyons, J., Zorn, T., Stewart, J., Seelbach, P., Wehrly, K., and Wang, L. 2009. Defining and Characterizing Cool water Streams and Their Fish Assemblages in Michigan and Wisconsin, USA. North American Journal of Fisheries Management, 29:1130-1151.

Appendix B.1. Table 1. Summary of MDFW Study Sites

Site ID	Event ID	Agency_ID	Watershed	Stream	Town	State	# Days	Start Date	End Date	AveTemp (°C)
MA Albe55	De_862751	Deer 04	Deerfield	Albee Br	Hawley	MA	54	8/12/2005	10/4/2005	15.5
MA Aver55	De_862757	Deer 10	Deerfield	Avery Br	Charlemont W.	MA	208	8/12/2005	4/12/2006	7.2
MA Bron55	We_870441	West 01	Westfield	Bronson Br	Chesterfield	MA	542	7/22/2005	5/15/2007	8.9
MA Clak55	De_870436	Deer 11	Deerfield	Clark Br	Buckland	MA	350	8/14/2005	9/19/2006	10.5
MA Cobb55	Na_870459	Na 03	Nashua	Cobb Br	Princeton	MA	706	8/19/2005	10/9/2007	11.7
MA Cold55	BL_870453	Bl 02	Blackstone	Cold Spring Br	Uxbridge	MA	778	8/19/2005	10/6/2007	9.6
MA Coll55	Mi_870454	Mil 01	Millers	Collar Br	Royalston	MA	713	7/21/2005	10/15/2007	11.4
MA Dunb55	De_862760	Deer 12	Deerfield	Dunbar Br	Monroe	MA	206	8/13/2005	10/18/2007	13.9
MA Fife55	De_862758	Deer 07	Deerfield	Fife Br	Florida	MA	755	8/13/2005	10/17/2007	8.3
MA Firs55	De_862759	Deer 02	Deerfield	First Br	Buckland	MA	355	8/6/2005	10/17/2007	10.7
MA Full55	We_870450	West 03	Westfield	Fuller Br	Worthington	MA	77	7/22/2005	10/6/2005	16.9
MA Gibb55	We_870445	West 05	Westfield	Gibbs Br	Blandford	MA	386	7/29/2005	9/2/2006	9.5
MA Gulf55	Mi_870437	Mil 02	Millers	Gulf Br	Athol	MA	740	7/21/2005	10/15/2007	10.2
MA Hawk55	De_862753	Deer 03	Deerfield	Hawkes Br	Charlemont	MA	55	8/11/2005	10/4/2005	14.4
MA HogH55	De_862763	Deer 01	Deerfield	Hog Hollow Br	Buckland	MA	680	8/6/2005	10/17/2007	10.4
MA Kear55	We_870439	West 02	Westfield	Kearney Br	Worthington	MA	754	7/22/2005	11/30/2007	9.4
MA Keyu55	Mi_870448	Mil 03	Millers	Keyup Br	Erving	MA	220	7/23/2005	4/17/2006	8.3
MA Lyon55	Mi_870449	Mil 04	Millers	Lyons Br	Wendell	MA	793	7/23/2005	10/15/2007	11.5
MA Mann55	De_862762	Deer 06	Deerfield	Manning Br	Florida	MA	54	8/13/2005	10/5/2005	14.1
MA Maxw55	De_862761	Deer 13	Deerfield	Maxwell Br	Charlemont	MA	314	8/12/2005	7/19/2006	8.1
MA Mayn55	Ch_870457	Ch 02	Chicopee	Maynard Br	Oakham	MA	622	8/19/2005	10/7/2007	12.7
MA Park55	Ch_870458	Ch 01	Chicopee	Parkers Br	Oakham	MA	779	8/19/2005	10/7/2007	10.7
MA Pleas55	Ch_870460	Ch 03	Chicopee	Pleasant Br	Barre	MA	708	8/19/2005	10/7/2007	11.3
MA Roar55	We_870443	West 06	Westfield	Roaring Br (1)	Montgomery	MA	743	7/29/2005	11/30/2007	10.4
MA Roar60	We_870447	West 04	Westfield	Roaring Br (2)	Chester	MA	744	7/22/2005	11/30/2007	11.8

Site ID	Event ID	Agency_ID	Watershed	Stream	Town	State	# Days	Start Date	End Date	Average Temp (°C)
MA Shak55	We_870442	West 09	Westfield	Shaker Mill Br	Becket	MA	70	7/29/2005	10/6/2005	15.7
MA Stag55	We_870444	West 07	Westfield	Stage Br	Blandford	MA	752	7/29/2005	11/30/2007	10.1
MA Stee55	De_862752	Deer 09	Deerfield	Steele Br	Rowe	MA	54	8/13/2005	10/5/2005	15.0
MA SWac55	Na_870462	Na 02	Nashua	S. Wachusett Br	Princeton	MA	625	10/6/2005	10/9/2007	10.4
MA Tiff55	We_870440	West 08	Westfield	Tiffany Br	Blandford	MA	362	7/29/2005	9/26/2006	10.6
MA Towe55	We_862754	West 10	Westfield	Tower Br	W. Chesterfield	MA	357	7/29/2005	9/21/2006	11.3
MA UntM55	Mi_870446	Mil 05	Millers	UNT to Millers River	Wendell	MA	756	7/23/2005	10/15/2007	10.2
MA Warr55	BL_870451	Bl 01	Blackstone	Warren Br	Upton	MA	685	8/19/2005	10/6/2007	11.3
MA Weke55	Na_870456	Na 01	Nashua	Wekepeke Br	Sterling	MA	397	8/19/2005	9/19/2006	11.4
MA Whet55	Mi_870438	Mil 06	Millers	Whetstone Br	Wendell	MA	719	7/23/2005	10/15/2007	10.6
MA Whit55	De_870435	Deer 08	Deerfield	Whitcomb Br	Florida	MA	54	8/13/2005	10/5/2005	14.3
MA WilB55	De_862756	Deer 05	Deerfield	Willis Br	Charlemont	MA	208	8/11/2005	4/11/2006	6.9

Appendix B.1. Table 2. Summary of CT DEEP Study Sites

Site ID	Event ID	Agency_ID	Watershed	Stream	Town	State	# Days	Start Date	End Date	AveTemp (°C)
CT_1083	2238834	1083	Salmon Brook	East Branch Salmon Brook	Granby	CT	105	5/21/2010	9/2/2010	19.10954
CT_1440	9715470	1440	Hubbard Brook	Sages Ravine Brook	Salisbury	CT	125	5/1/2010	9/2/2010	14.42996
CT_1456	9715466	1456	Nelson Brook-Willimantic River	Bone Mill Brook	Tolland	CT	145	5/1/2010	9/22/2010	15.14582
CT_1916	2238845	1916	Nod Brook-Farmington River	Thompson Brook	Avon	CT	114	5/16/2010	9/6/2010	14.39261
CT_2295	1086409	2295	Roaring Brook	Mott Hill Brook	Glastonbury	CT	56	5/6/2010	6/30/2010	14.74525
CT_2394	9715462	2394	West Branch Naugatuck River	Hall Meadow Brook	Norfolk	CT	125	5/1/2010	9/2/2010	16.59128
CT_2515	9725746	2515	Lower Scantic River	Gulf Stream	Somers	CT	136	5/1/2010	9/13/2010	16.92852
CT_359	2238833	359	West Branch Salmon Brook	West Branch Salmon Brook	Granby	CT	105	5/21/2010	9/2/2010	18.78827
CT_480	2238856	480	Merrick Brook	Merrick Brook	Scotland	CT	134	5/10/2010	9/20/2010	18.06254
CT_606	2238828	606	Ashaway River	Green Fall River	North Stonington	CT	149	5/10/2010	10/5/2010	17.95055
CT_717	2238837	717	Lower West Branch Farmington River	Mallory Brook	Barkhamsted	CT	135	5/13/2010	9/24/2010	16.26173

Appendix B.1. Table 3. Selected statistics for average daily mean values summarized by month for MDFW and CT DEEP Sites.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MDFW Sites												
N	29	20	28	26	25	27	27	37	37	30	29	28
Mean	2.1	1.5	2.3	6.8	11.7	15.4	18.1	17.1	14.6	10.6	6.2	2.6
Std Dev	0.5	0.5	0.7	1.5	2.0	2.1	2.2	1.4	0.9	0.7	0.8	0.7
Std Err Mean	0.1	0.1	0.1	0.3	0.4	0.4	0.4	0.2	0.1	0.1	0.1	0.1
Upper 95%	2.3	1.7	2.6	7.4	12.5	16.2	19.0	17.6	14.9	10.9	6.4	2.8
Lower 95%	1.9	1.3	2.0	6.2	10.9	14.5	17.2	16.6	14.3	10.4	5.9	2.3
maximum	3.1	2.6	4.7	10.6	16.1	19.0	22.3	19.9	16.6	11.9	8.4	4.1
75%	2.4	1.8	2.5	7.7	13.4	17.6	20.3	17.9	15.0	11.1	6.6	3.1
median	2.0	1.4	2.1	6.6	11.4	15.1	17.9	17.0	14.5	10.5	6.1	2.6
25%	1.7	1.1	1.9	5.6	9.9	13.9	16.3	16.2	14.0	10.2	5.6	2.1
minimum	0.8	0.7	1.6	4.7	8.7	11.2	13.6	14.0	12.5	9.2	5.0	1.3
CT DEEP Sites												
N					11	11	10	10				
Mean					13.8	16.4	18.9	17.6				
Std Dev					2.0	1.4	2.0	1.7				
Std Err Mean					0.6	0.4	0.6	0.5				
Upper 95%					15.2	17.3	20.3	18.8				
Lower 95%					12.5	15.4	17.4	16.4				
maximum					18.3	18.4	20.7	19.3				
75%					14.6	17.8	20.6	19.0				
median					13.5	16.4	19.3	18.0				
25%					12.5	15.0	17.0	16.2				
minimum					11.2	14.3	15.0	14.1				

Appendix B.1. Table 4. Selected statistics for average of daily minimum values summarized by month for MDFW and CT DEEP Sites.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MDFW Sites												
N	29	20	28	26	25	27	27	37	37	30	29	28
Mean	1.5	1.1	1.4	5.3	10.3	14.2	17.0	16.1	13.5	9.8	5.3	2.0
Std Dev	0.5	0.4	0.6	1.4	1.8	1.8	1.9	1.2	0.8	0.6	0.8	0.6
Std Err Mean	0.1	0.1	0.1	0.3	0.4	0.3	0.4	0.2	0.1	0.1	0.1	0.1
Upper 95%	1.7	1.3	1.6	5.9	11.1	14.9	17.8	16.5	13.8	10.0	5.6	2.2
Lower 95%	1.3	0.9	1.1	4.8	9.6	13.5	16.2	15.7	13.3	9.5	5.0	1.7
maximum	2.3	1.8	3.0	8.6	14.7	17.2	20.6	18.5	15.3	11.1	7.4	3.4
75.00%	2.0	1.4	1.7	6.1	11.9	16.1	19.0	16.7	14.0	10.2	5.9	2.4
median	1.5	1.1	1.2	5.0	10.3	14.1	16.9	16.2	13.5	9.7	5.1	1.9
25.00%	1.2	0.8	1.0	4.3	8.7	13.1	15.5	15.3	13.0	9.4	4.7	1.5
minimum	0.4	0.5	0.7	3.4	7.5	10.6	13.0	13.3	11.8	8.2	4.2	0.9
CT DEEP Sites												
N					11	11	10	10				
Mean					12.6	15.4	17.8	16.6				
Std Dev					1.9	1.4	1.9	1.4				
Std Err Mean					0.6	0.4	0.6	0.5				
Upper 95%					13.8	16.3	19.1	17.7				
Lower 95%					11.3	14.5	16.4	15.6				
maximum					17.1	17.4	19.8	18.4				
75%					13.2	16.9	19.5	17.8				
median					12.1	15.3	18.0	16.9				
25%					11.4	14.0	16.0	15.3				
minimum					10.6	13.3	14.2	13.9				

Appendix B.1. Table 5. Selected statistics for average of daily maximum values summarized by month for MDFW and CT DEEP Sites.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MDFW Sites												
N	29	20	28	26	25	27	27	37	37	30	29	28
Mean	2.6	1.9	3.4	8.4	13.1	16.6	19.3	18.2	15.6	11.5	7.0	3.1
Std Dev	0.6	0.6	1.0	1.7	2.2	2.5	2.6	1.7	1.1	0.7	0.7	0.8
Std Err Mean	0.1	0.1	0.2	0.3	0.4	0.5	0.5	0.3	0.2	0.1	0.1	0.1
Upper 95%	2.9	2.2	3.8	9.1	14.1	17.6	20.3	18.7	16.0	11.7	7.3	3.4
Lower 95%	2.4	1.6	3.0	7.7	12.2	15.6	18.3	17.6	15.2	11.2	6.7	2.8
maximum	3.8	3.6	6.6	12.9	17.7	21.6	24.0	21.8	18.3	12.8	9.3	4.9
75.00%	3.0	2.3	3.6	9.9	15.0	19.0	21.9	19.1	16.0	12.0	7.3	3.6
median	2.6	1.7	3.1	8.2	12.7	16.1	19.1	17.9	15.4	11.3	6.9	3.1
25.00%	2.3	1.5	2.7	7.0	11.2	14.6	17.2	17.0	14.9	10.9	6.5	2.6
minimum	1.3	1.0	2.3	5.8	10.0	11.9	14.3	14.6	13.1	10.2	5.8	1.7
CT DEEP Sites												
N					11	11	10	10				
Mean					15.3	17.5	20.2	18.7				
Std Dev					2.1	1.6	2.3	2.1				
Std Err Mean					0.6	0.5	0.7	0.7				
Upper 95%					16.7	18.5	21.8	20.2				
Lower 95%					13.8	16.4	18.5	17.2				
maximum					19.4	19.5	23.0	21.2				
75%					16.0	19.3	21.9	20.3				
median					14.6	17.6	20.8	19.0				
25%					14.0	16.1	18.0	17.2				
minimum					12.0	14.8	16.1	14.6				