2010

Temperature Characteristics of Cold Water Fish Habitat

Connecticut Department of Energy and Environmental Protection
Bureau of Water Protection and Land Reuse
79 Elm Street, Hartford, CT 06106

Characterization of Water Temperature in Cold Water Fish Habitat: Project Status Report Year 1 of 5, Summer-2010

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Executive summary: During the 2010 water quality standard review process water temperature was identified as parameter of interest. In order to propose changes to the current temperature standard a review of both water temperature and fish community was conducted. Although an extensive data set does exist for hundreds of site locations across the state there was a significant data gap for true "cold" water habitat. To fill this data need Connecticut Department of Energy and Environmental Protection (DEEP) needed to obtain this type of data. To that end 11 site locations were selected for temperature monitoring due to the presence of well established population of *Cottus cognatus* (slimy sculpin), a cold water stenotherm or known cold water temperatures via historical WPLR point sampling data. Water temperature probes (ONSET HOBO water temp pro) were placed instream from May 2010-September 2010 to capture summertime temperature conditions. The purpose of this document is to present water temperature data collected at these locations so to better inform management decisions regarding coldwater habitat. It is recommended that beginning in 2011 water temperature data be collected year round at these same locations for a period of at least 5 years so to capture natural climate variability. Through sufficient water temperature data were not available at the time of the 2010 water quality standards revisions; this project should produce Connecticut specific coldwater habitat data for the 2013 water quality standard review. Inquiry regarding this project should be directed to mike.beauchene@ct.gov

Background: Water temperature is an important influence of fish communities. Factors influencing water temperature can be both natural and/or anthropogenic. Natural factors include elevation, channel gradient and orientation, surficial geology and groundwater input, air temperature and even *Canor canadensis* (beaver). While human factors include impervious surface, groundwater withdrawal and stream diversion, damming, and point source discharges.

Hourly water temperature data have been collected by the Bureau of Water Protection and Land Reuse (WPLR) and Inland Fisheries using HOBO water temperature probes since 1998. As of 2010 over 1330 deployments at 483 site locations have occurred all stored in a Microsoft Access database consisting of over 4.5 million temperature values. Fish community structure has been collected by inland fisheries and WPLR since 1999 with over 969 samples from 678 site locations to date. Unfortunately much of this data does not contain paired water temperature and fish community data. For example, a site location could have fish community data from 1999 and water temperature data from 2005 or there could be only fish and not temperature and vice versa.

Since true cold water temperature values were underrepresented in the water temperature data set, WPLR identified 11 cold water habitat site locations using previously collected fish community samples and placed 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 cold water stenotherms.

Approach: Candidate sites were selected using database queries to search for established populations of *Cottus cognatus* (greater than 5 individuals in a sample reach). Due to a variety of factors including limited distribution of this fish species, human disturbance, and minimal cold

water habitat no sites were located in southwestern Connecticut (Figure 1 & Table 1). Water temperature probes were deployed in April to May 2010 and were removed by 9/30/2010 at the latest (DEEP HOBO SOP). For consistent data analysis only values recorded between 6/1/2010 and 8/31/2010 are evaluated. In Connecticut, the months of June-July-August typically have the warmest stream temperatures. Fish community data were collecting using backpack mounted or tote-barge electrofishing gear. All species in the sample reach are netted, measured to nearest centimeter, and released back to the stream (DEEP Fish Community QAPP). WPLR has been deploying HOBO water temperature probes in a variety of streams across the state since 2004. Data for 2010 from 10 sites were selected from this set to compare to the cold water data.

Cottus cognatus (slimy sculpin) a cold water stenotherm (photo courtesy of Robert Jacobs)

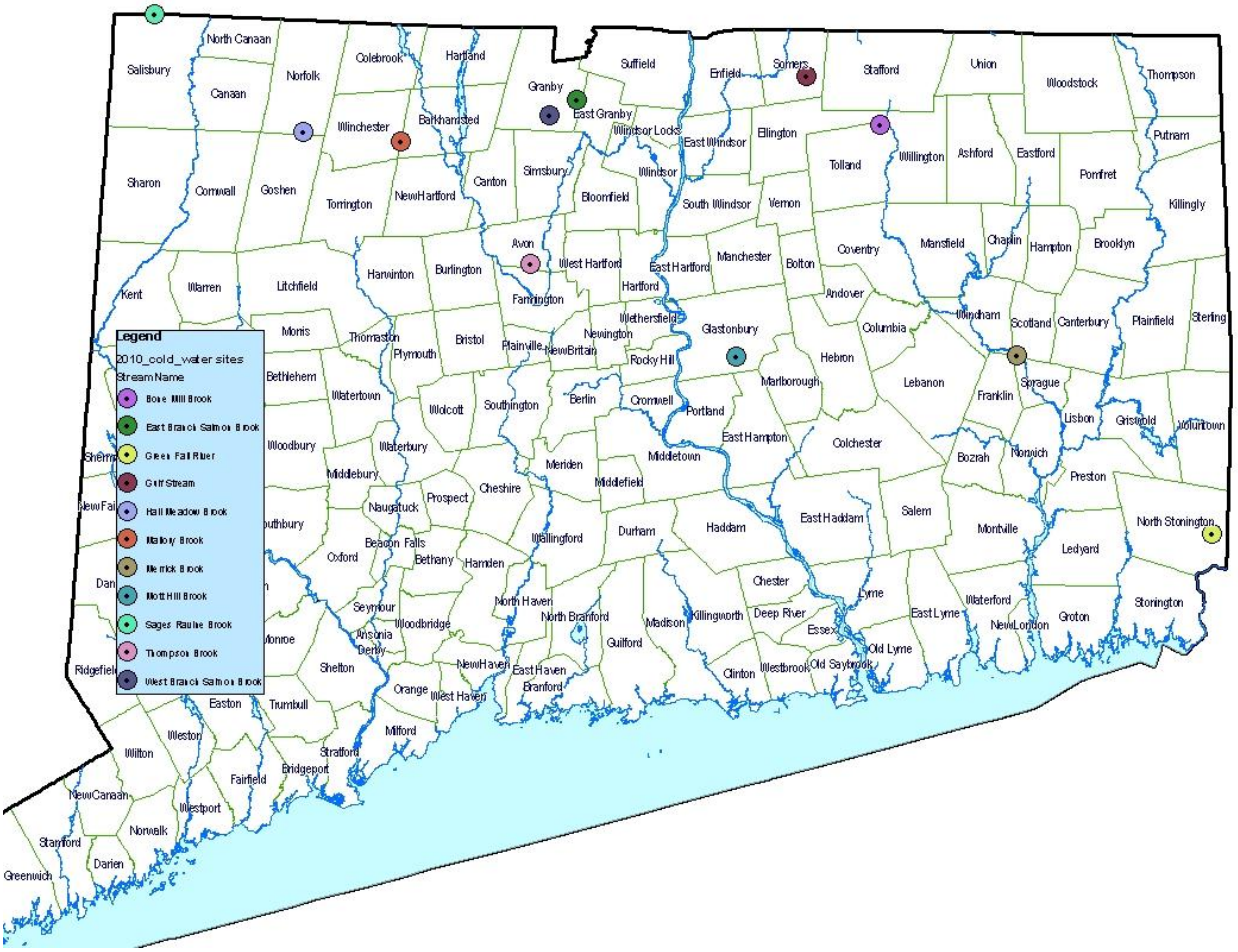


Figure 1. Location of the 11 cold water sites selected for water temperature monitoring during summer 2010.

Table 1. Location information for the 11 cold water sites selected for water temperature monitoring during summer 2010.

stream name	station id	proximity	landmark	basinid	Municipality	YLat	XLong
Bone Mill Brook	1456	upstream	end of driveable road above sweet heart lake	3100	Tolland	41.924	-72.316
East Branch Salmon Brook	1083	Downstream	Route 20	4320	Granby	41.955	-72.779
Green falls	606	upstream	confluence with Wyassup Bk US Clarks Fall Rd.	1002	North Stonington	41.456	-71.816
Gulf Stream	2515	adjacent	Wells Road	4203	Somers	41.981	-72.428
Hall Meadow Brook	2394	adjacent to Rte 272	across from South Norfolk lumber company	6901	Norfolk	41.9173	-73.1949
Mallory Brook	717	above	gas pipeline	4305	Barkhamsted	41.906	-73.047
Merrick Brook	480	at	Station Road	3803	Scotland	41.661	-72.110
Mott Hill Brook	2295	off Hunt Ridge Drive	at Private Drive for houses # 107-109	4008	Glastonbury	41.661	-72.536
Sages Ravine Brook	1440	downstream	Route 41	6001	Salisbury	42.049	-73.424
Thompson Brook	1916	at	Bike Path Crossing (Old RR grade)	4316	Avon	41.768	-72.849
West Branch Salmon Brook	359	upstream 50 meters	Barndoor Road	4319	Granby	41.937	-72.821

Sages Ravine Brook, Salisbury, CT. June 2010.

Key Findings:

*Summer 2010 was the second warmest on record in New England. These exceptionally warm air temperatures were coupled with scant precipitation resulting in near record low stream flow especially in northwestern Connecticut. The combination of low stream flow and high air temperatures could represent a worst-case scenario for these site locations.

*The maximum air temperature at Bradley International airport was 38 C (102 F) [Figure 2].

*31 days had maximum air temperature over 32 C (90 F) at Bradley International Airport. The average is 18 days with the record being 38.

*In contrast observations from the Green Mountain Forest in Norfolk, CT only had 2 days, both in July, with maximum air temperature over 32 C (90 F). http://www.greatmountainforest.org/weather/weather-by-the-month.html

*Stream flow steadily decreased from median values in June to near record lows in September [Figure 3].

*24,288 data points were collected from the 11 cold water site locations between June, July and August 2010 [Table 2 and Figure 4].

*The median value for the data set was 17.2 C with 50% of the observations were between 15.2 C and 19.3 C [Table 2].

*The maximum recorded temperature for any of the 11 coldwater habitat sites was 25.4 C at the West Branch Salmon Brook site [Table 3].

*Coolest streams were Sages Ravine Brook, Bonemill Brook, Thompson Brook, and Mott Hill Brook [Figure 5].

*All coldwater sites except Mott Hill Brook and Thompson Brook had highest temperatures during July [Figure 6].

*All sites had even distribution of temperature values across June, July and August except for Sages Ravine Brook and Thompson Brook which had very consistent temperature in August as indicated by a large peak in the histogram [Figure 7 and Table 4].

*Individual dot plots by site and month show consistent cold water temperatures in August at Mott Hill Brook, Sages Ravine Brook and Thompson Brook [Figure 8].

*Water temperature data for the selected long-term sites for comparison to coldwater sites were typically warmer [Figure 9 and Table 5].

*The distribution of the data are much lower at the cold water sites than the selected long-term comparison sites [Figure 10].

*Maximum values for coldwater sites were mostly lower than 25th percentile for the 10 selected long-term comparison sites [Figure 10].

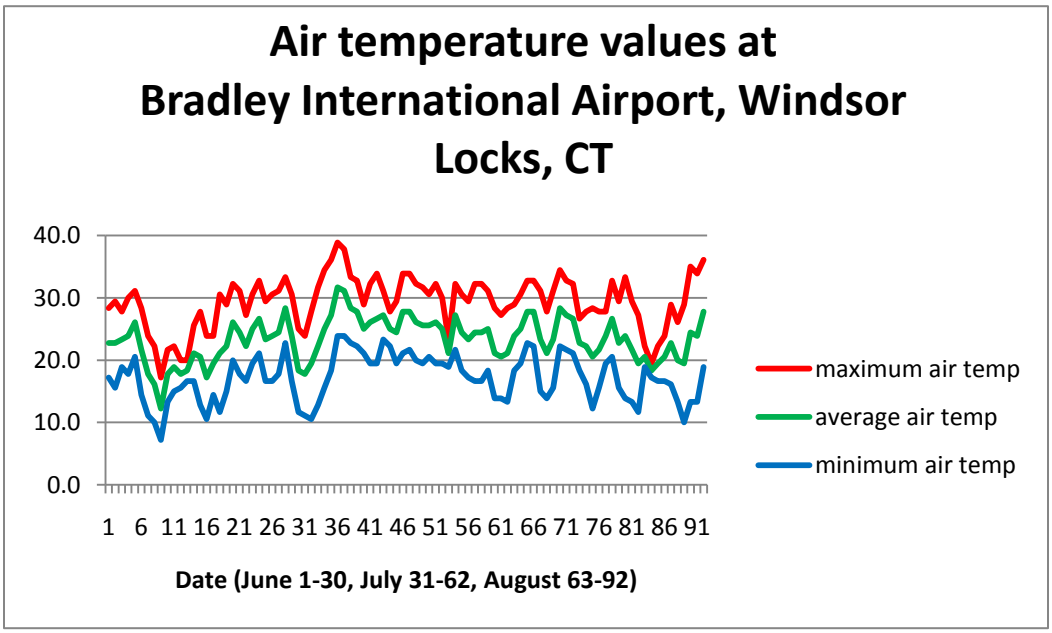


Figure 2. Plot of maximum, minimum and average air temperature recorded at Bradley International Airport during June, July, and August 2010.

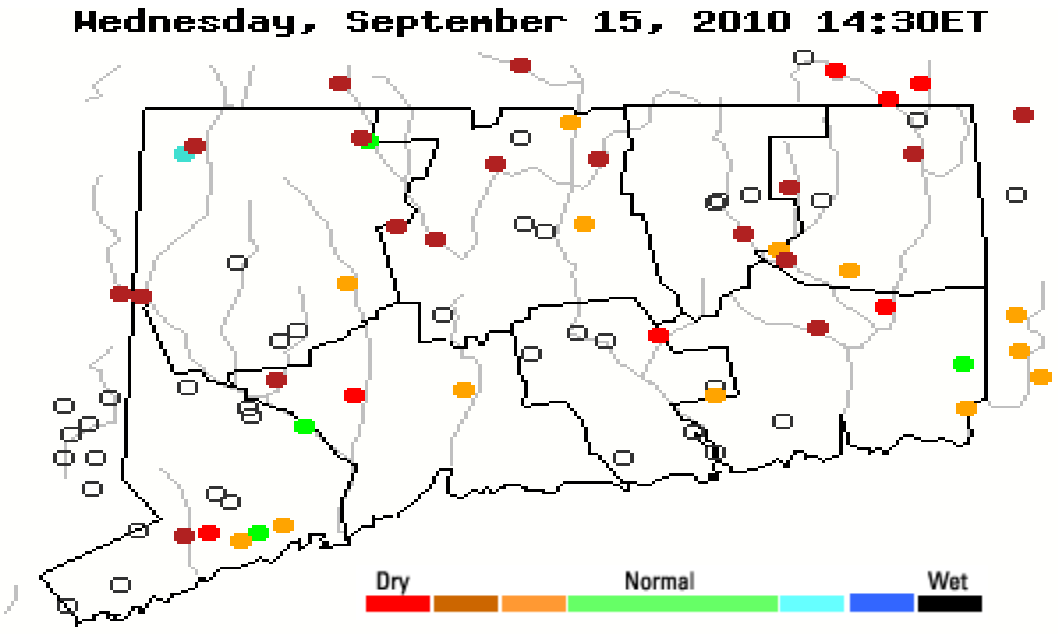


Figure 3. Stream flow as compared to historical values from USGS gages across Connecticut for September 15, 2010. Very little precipitation during July, August and early September created near record low stream flow for many gage sites across the state.

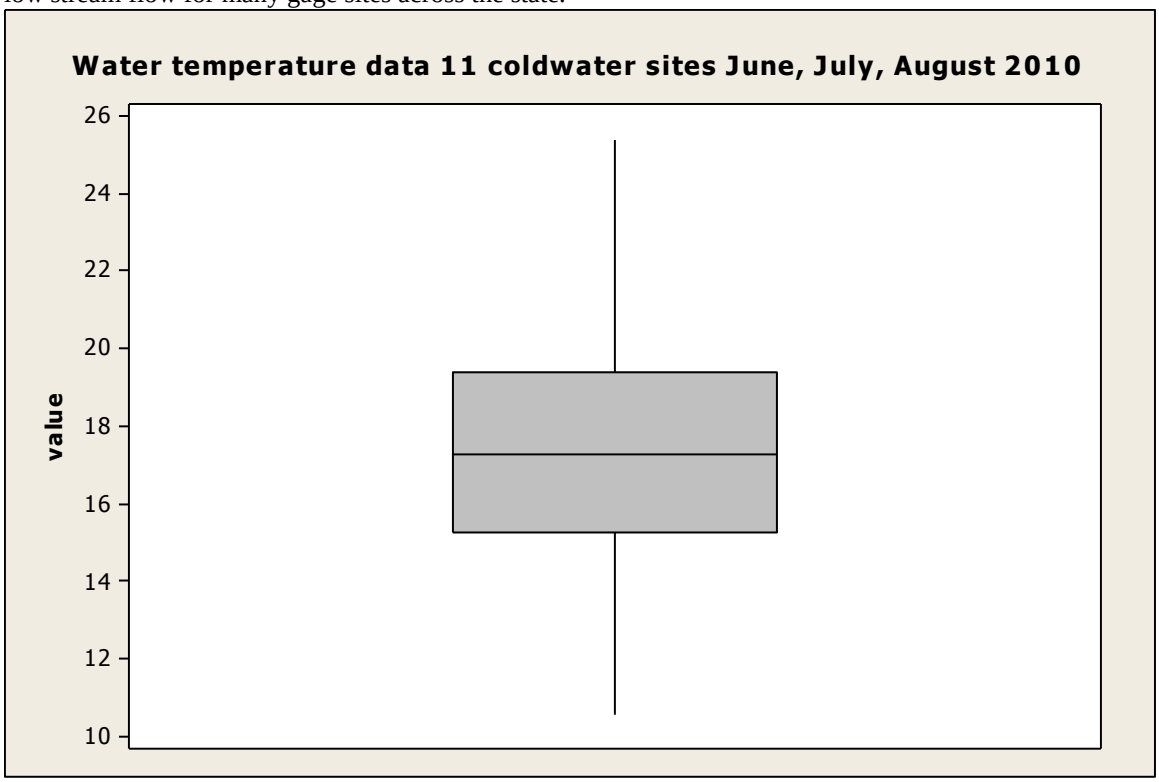


Figure 4. Box and whisker plot of all temperature values recorded from June, July, and August 2010 from the 11 selected cold water sites.

Table 2. Select statistics for all temperature values recorded from June, July, and August 2010 from the 11 selected cold water sites.

Statistic	Value
N	24288
Mean	17.325 C
StDev	2.721
minimum	10.59 C
Q1	15.27 C
Median	17.296 C
Q3	19.389 C
Maximum	25.38 C
Range	14.79

Table 3. Select statistics by station for all temperature values recorded from June, July, and August 2010 from the 11 selected cold water sites.

Stream name- station id	N	Mean	StDev	Variance	Minimum	25th	Median	75th	Maximum	Range
West Branch Salmon Brook-359	2206	19.1	2.4	5.6	12.7	17.4	19.2	20.7	25.4	12.7
Merrick Brook-480	2206	19.2	2.2	4.9	12.9	17.7	19.5	21.0	23.9	11.0
Green Fall River-606	2206	19.3	2.1	4.5	13.2	17.8	19.4	21.0	23.1	10.0
Mallory Brook-717	2206	17.4	2.3	5.2	10.6	15.9	17.6	19.1	22.1	11.5
East Branch Salmon Brook-1083	2206	19.2	2.0	4.0	13.8	17.7	19.2	20.7	24.5	10.7
Sages Ravine Brook-1440	2206	15.5	1.4	2.0	11.2	14.7	15.6	16.7	18.6	7.3
Bone Mill Brook-1456	2206	16.2	1.8	3.1	10.6	15.0	16.4	17.5	20.5	9.9
Thompson Brook-1916	2206	14.5	1.1	1.2	11.3	13.7	14.4	15.2	20.2	8.9
Mott Hill Brook-2295	2206	14.2	2.1	4.5	11.2	12.3	13.5	15.9	20.4	9.2
Hall Meadow Brook-2394	2206	17.7	2.0	4.0	11.8	16.3	17.8	19.3	21.9	10.1
Gulf Stream-2515	2206	18.2	2.3	5.2	11.7	16.8	18.4	19.9	24.4	12.6

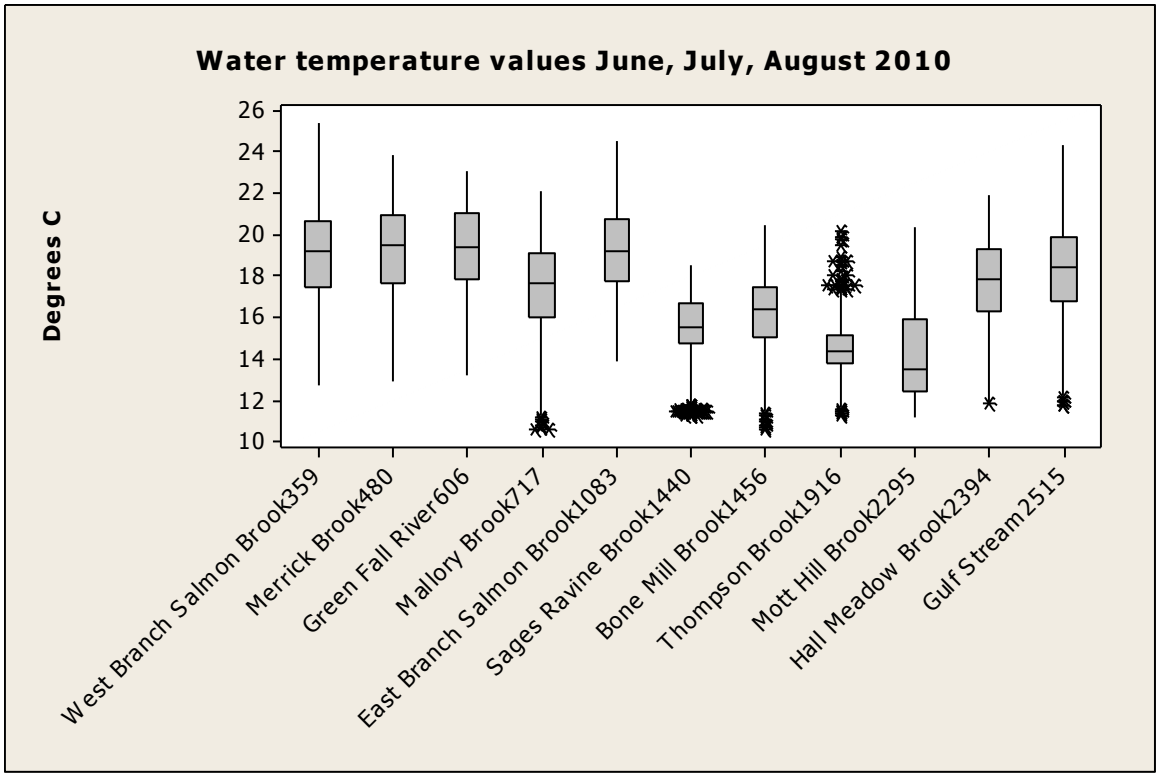


Figure 5. Box and whisker plot of all temperature values recorded for each of the 11 cold water stations from June, July, and August 2010.

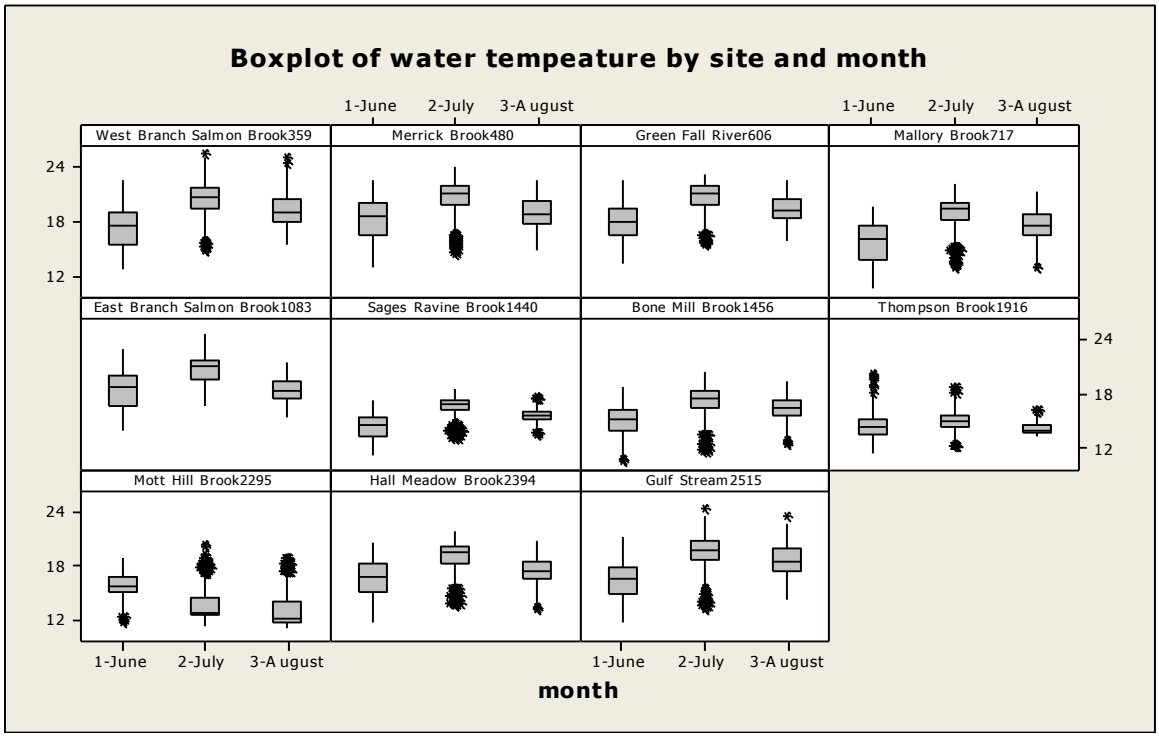


Figure 6. Box and whisker plot of all temperature values recorded by site and by month for each of the 11 cold water stations June, July, and August 2010.

Table 4. Select statistics for all temperature values recorded by site and by month for each of the 11 cold water stations June, July, and August 2010.

Stream - station id	month	N	Mean	StDev	Minimum	25th	median	75th	Maximum
West Branch Salmon Brook-359	1-Jun	718	17.4	2.2	12.7	15.5	17.5	19.0	22.5
	2-Jul	744	20.5	1.9	14.7	19.4	20.6	21.8	25.4
	3-Aug	744	19.2	1.8	15.3	17.8	19.0	20.5	25.0
Merrick Brook-480	1-Jun	718	18.1	2.2	12.9	16.4	18.4	20.0	22.6
	2-Jul	744	20.6	1.9	14.4	19.8	21.1	21.9	23.9
	3-Aug	744	18.9	1.6	14.7	17.7	18.7	20.1	22.6
Green Fall River-606	1-Jun	718	17.8	2.1	13.2	16.5	17.9	19.4	22.5
	2-Jul	744	20.7	1.7	15.5	19.8	21.1	21.9	23.1
	3-Aug	744	19.3	1.4	15.9	18.3	19.2	20.4	22.5
Mallory Brook-717	1-Jun	718	15.7	2.1	10.6	13.8	16.0	17.4	19.5
	2-Jul	744	18.8	1.9	12.9	18.1	19.3	20.0	22.1
	3-Aug	744	17.6	1.7	12.8	16.4	17.6	18.8	21.3
East Branch Salmon Brook-1083	1-Jun	718	18.4	2.1	13.8	16.5	18.7	19.9	22.9
	2-Jul	744	20.7	1.6	16.7	19.7	20.9	21.7	24.5
	3-Aug	744	18.5	1.3	15.4	17.5	18.4	19.4	21.4
Sages Ravine Brook-1440	1-Jun	718	14.3	1.4	11.2	13.4	14.6	15.3	17.2
	2-Jul	744	16.4	1.2	13.0	16.2	16.8	17.2	18.6
	3-Aug	744	15.6	0.7	13.5	15.2	15.5	16.1	17.6
Bone Mill Brook-1456	1-Jun	718	15.0	1.5	10.6	14.0	15.1	16.1	18.7
	2-Jul	744	17.2	1.7	11.7	16.4	17.4	18.4	20.5
	3-Aug	744	16.5	1.3	12.5	15.6	16.4	17.3	19.3
Thompson Brook-1916	1-Jun	718	14.4	1.4	11.3	13.4	14.3	15.2	20.2
	2-Jul	744	15.0	1.0	12.1	14.3	14.9	15.7	18.7
	3-Aug	744	14.1	0.6	13.2	13.7	13.9	14.6	16.1
Mott Hill Brook-2295	1-Jun	718	15.9	1.5	11.9	15.1	15.8	16.9	18.9
	2-Jul	744	13.6	1.7	11.4	12.6	12.9	14.4	20.4
	3-Aug	744	13.2	2.0	11.2	11.8	12.2	14.1	19.0
Hall Meadow Brook-2394	1-Jun	718	16.6	2.0	11.8	15.1	16.8	18.3	20.7
	2-Jul	744	19.0	1.8	13.6	18.3	19.5	20.2	21.9
	3-Aug	744	17.5	1.5	13.3	16.6	17.4	18.5	20.8
Gulf Stream-2515	1-Jun	718	16.4	2.0	11.7	14.9	16.6	17.8	21.2
	2-Jul	744	19.5	2.0	13.3	18.7	19.8	20.8	24.4
	3-Aug	744	18.7	1.6	14.3	17.5	18.6	19.9	23.5

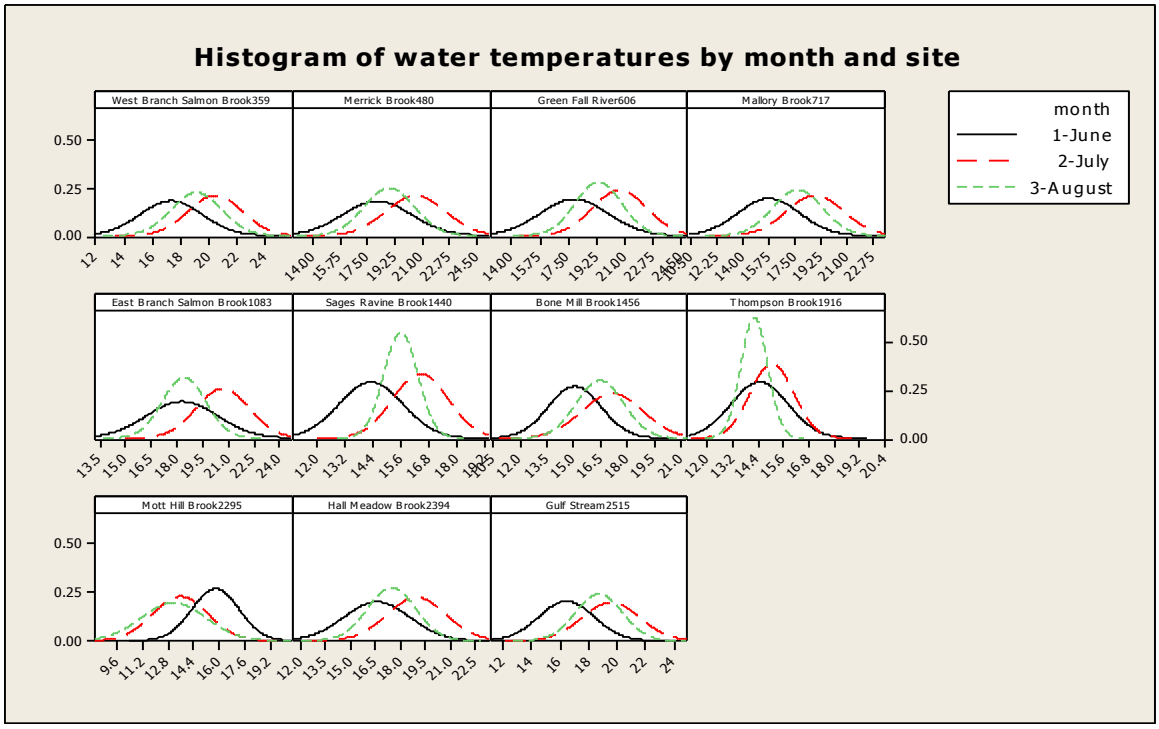


Figure 7. Histograms of water temperature data by site and by month for the 11 cold water sites June, July and August 2010. Note the high peak for August data in both Sages Ravine Brook and Thompson Brook meaning water temperatures were within a very narrow range and did not vary for much of the month.

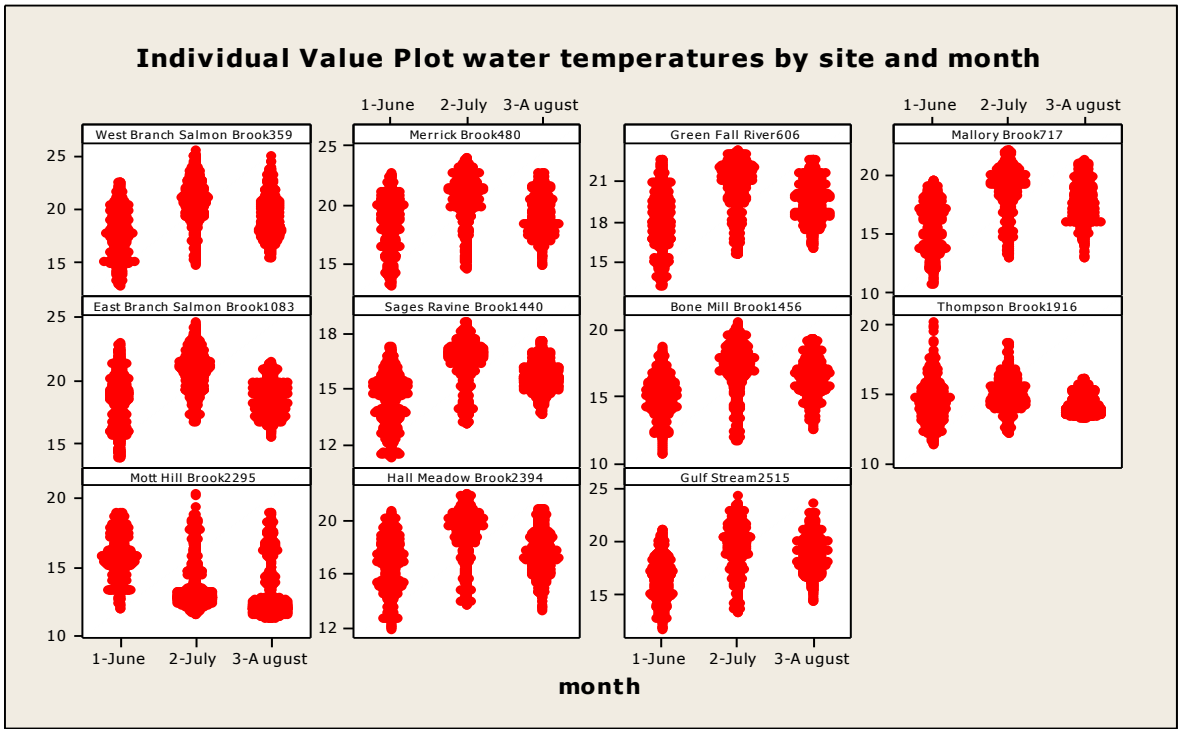


Figure 8. Individual dot plot graphs for water temperature data by site and by month for the 11 cold water sites during June, July and August 2010.

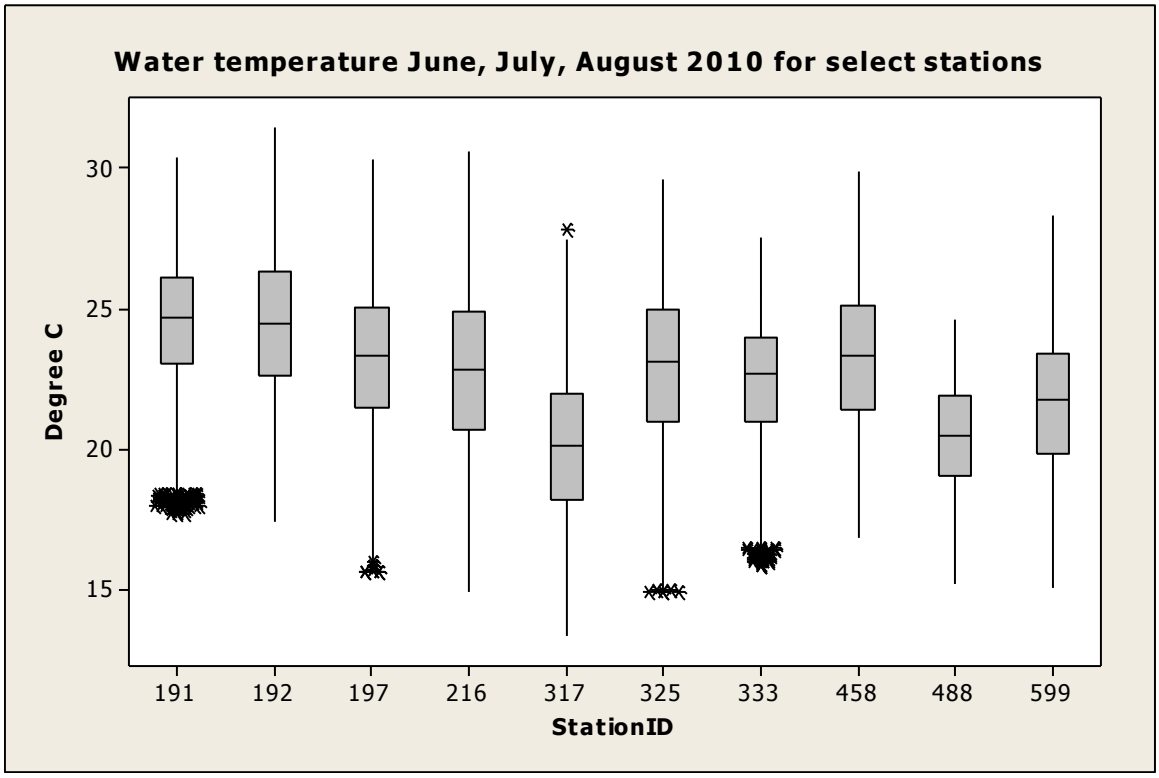
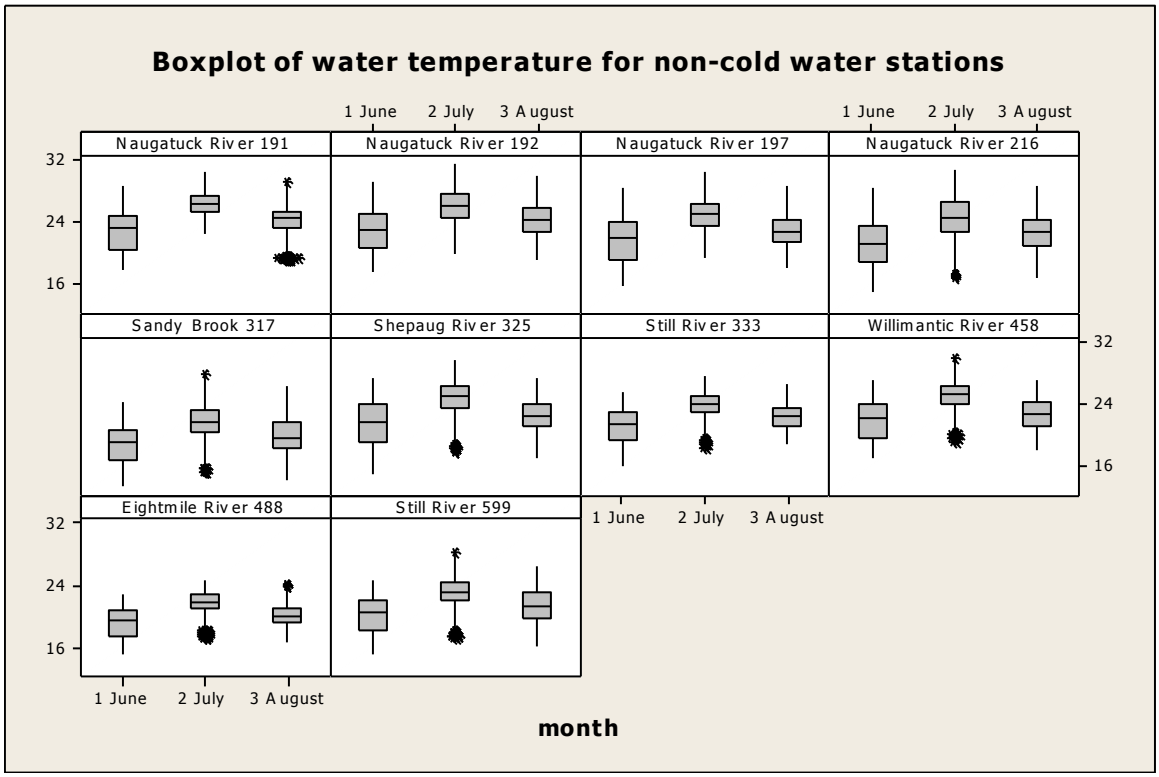
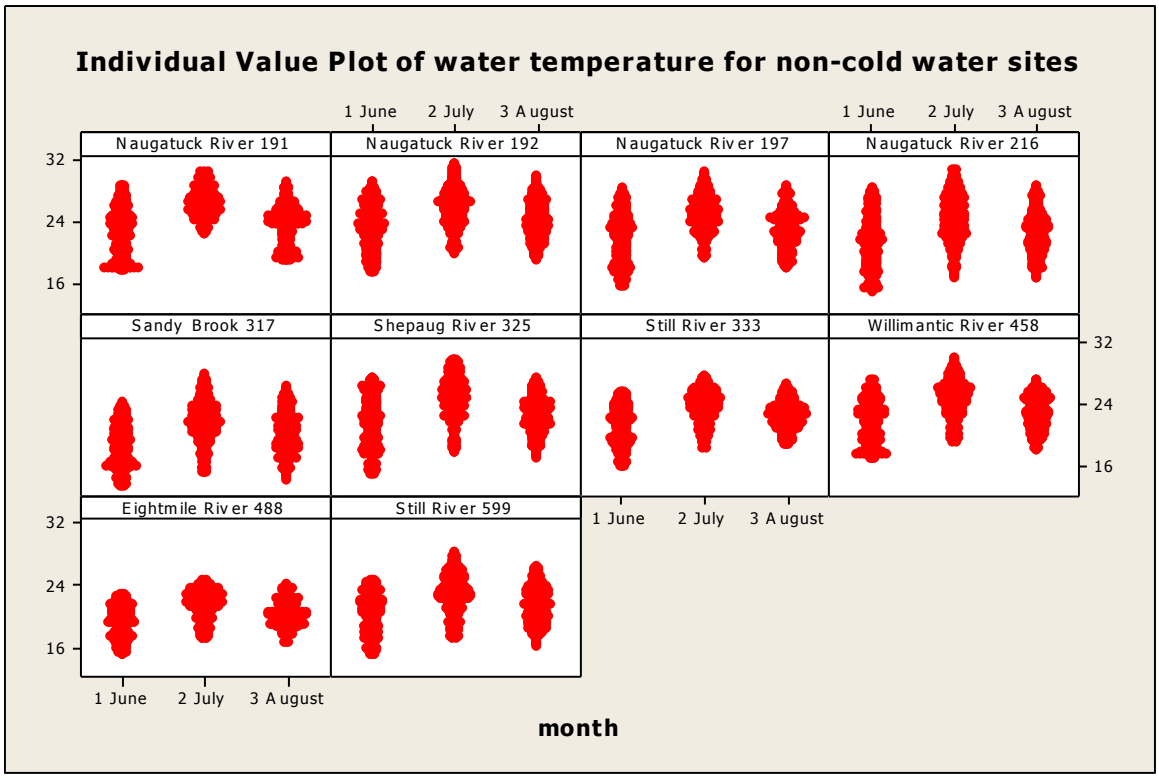


Figure 9. Box and whisker plot of all temperature values recorded for each of the 10 selected long-term water temperature monitoring stations from June, July, and August 2010.

Table 5. Select statistics by station for each of the 10 selected long-term water temperature monitoring stations from June, July, and August 2010.

Stream name-station id	N	Mean	StDev	Minimum	25th	Median	75th	Maximum	Range
Naugatuck River-191	2208	24.319	2.69	17.677	23.04	24.6	26.134	30.369	12.692
Naugatuck River-192	2208	24.31	2.731	17.368	22.585	24.4	26.298	31.433	14.065
Naugatuck River-197	2208	23.107	2.77	15.605	21.437	23.316	25.04	30.318	14.713
Naugatuck River-216	2208	22.739	3.047	14.936	20.674	22.8	24.919	30.621	15.685
Sandy Brook-317	2208	20.064	2.684	13.353	18.176	20.1	21.957	27.801	14.448
Shepaug River-325	4416	22.847	2.873	14.912	20.984	23.1	24.992	29.615	14.703
Still River -333	2208	22.423	2.199	15.819	20.984	22.6	23.978	27.53	11.711
Willimantic River-458	2208	23.142	2.599	16.844	21.413	23.3	25.089	29.865	13.021
Eightmile River-488	2208	20.367	1.936	15.175	19.056	20.4	21.867	24.629	9.454
Still River -599	2208	21.572	2.556	15.031	19.841	21.7	23.376	28.295	13.264


Boxplot of water temperature for non-cold water stations
Naugatuck River 191
Naugatuck River 192
Naugatuck River 197
Naugatuck River 216
Sandy Brook 317
Shepaug River 325
Still River 333
Willimantic River 458
Eightmile River 488
Still River 599
1 June
2 July
3 August
32
24
16
month


Individual Value Plot of water temperature for non-cold water sites
Naugatuck River 191
Naugatuck River 192
Naugatuck River 197
Naugatuck River 216
Sandy Brook 317
Shepaug River 325
Still River 333
Willimantic River 458
Eightmile River 488
Still River 599
1 June
2 July
3 August
32
24
16
month

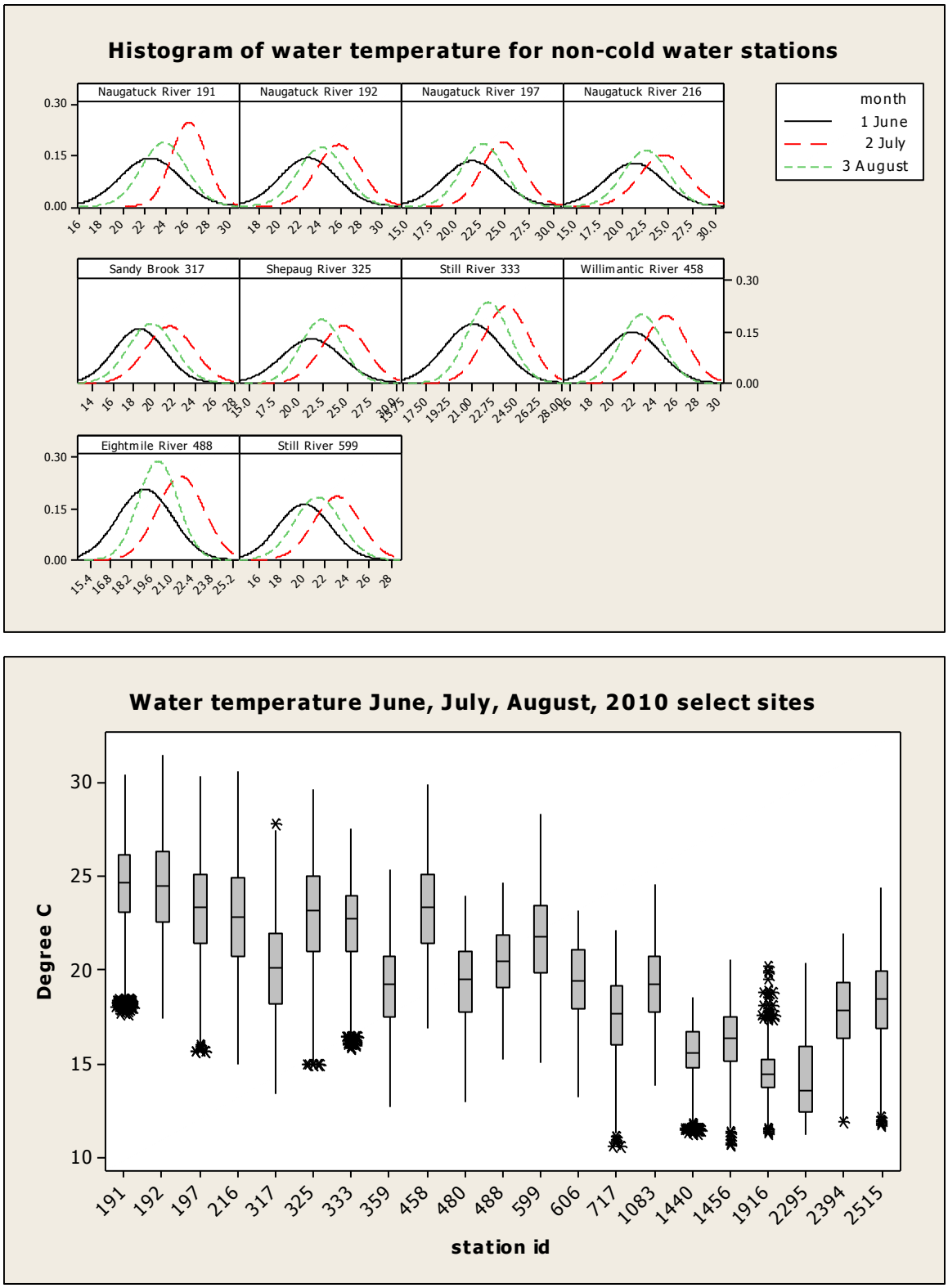


Figure 10. Box and whisker plots of water temperature data for selected long-term water temperature monitoring sites and the 11 cold water sites for June, July, and August 2010. Selected long-term sites are on the left side of the graph and are station id 191 to 599. The 11 cold water sites are on the right side of the graph and are station id 606-2515.

Food For Thought:

With the warmest temperatures on record coupled with very low surface runoff via precipitation it was thought data may represent worst case (warmest) temperature scenario for cold water streams. It appears that in these selected coldwater streams temperature is not as influenced by warm air temperatures as may be hypothesized but instead is stabilized due to the in stream flow being nearly 100% direct groundwater discharge.

Connecticut's cold water fish habitat is predicted, as is other temperature sensitive habitat and fauna worldwide to decline if climate change creates detrimental conditions due to decreased ground water and increased ambient air temperatures.

There remains a need to obtain adequate water temperature data from this habitat type so to better refine water quality standards in order to reduce loss of habitat due to localized human effects.

Continue to evaluate these data for at least the next 4 years so to understand natural climate variability and its role in water temperature of cold water and other stream habitats.

Regional climate change work group have begun to try and classify select macroinvertebrate taxa as potential indicators of cold water habitat. This water temperature data coupled with macroinvertebrate sampling at these location could be beneficial to this effort.

Much of our current work has been located in cool to warm reaches of streams and rivers of the state. Very little has been done in the cold water reaches [Figure 11].

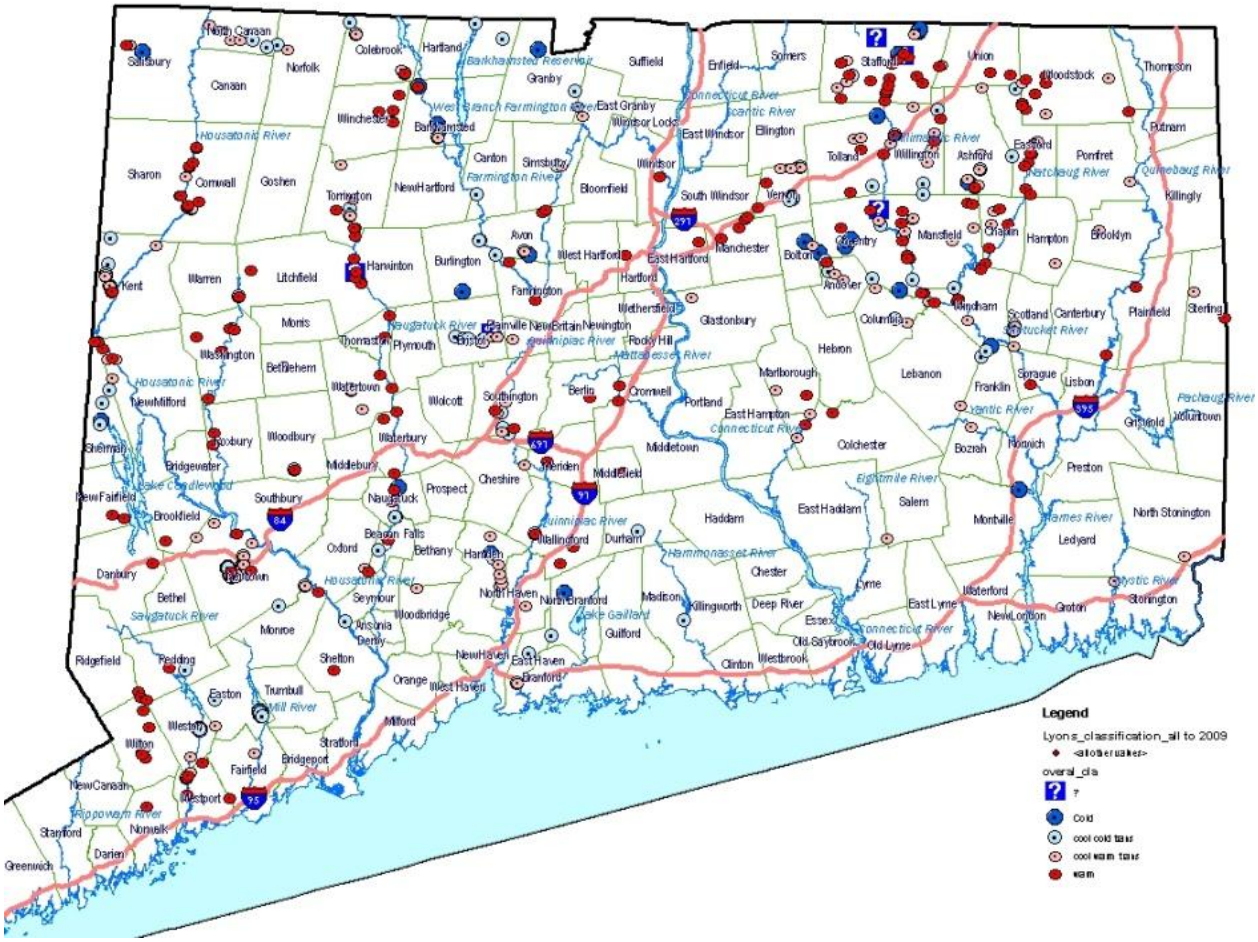


Figure 11. Water temperature habitat classification based upon HOBO water temperature data from both inland fisheries and WPLR from 1998-2009. Determination of classification was based upon ranges presented in Lyons et al 2009.

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