2011

Temperature Characteristics of Cold Water Fish Habitat

Connecticut Department of Energy &
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 2 of 5, Summer-2010 and 2011

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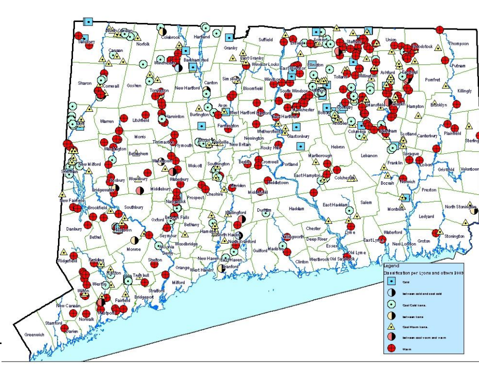
Summary: The purpose of this document is to present a summary of summer water temperature data collected during 2010 and 2011 as part of this project. In addition to summer data collection year-round data are currently being collected in order to characterize water temperature regime in non-summer months. The intent of the data is to support management decisions regarding coldwater fish habitat. During the second summer, hourly water temperature data were collected from 11 waterbodies. Unfortunately due to record rainfall and resulting flooding from Tropical Storm *Irene* and Tropical depression *Lee* in August and September, two probes were lost. Data for summer 2011 had a slightly higher median value but maximum values were lower than 2010. Probes were exchanged in the fall of 2011 with the intent to collect year round data from these locations. Inquiry regarding this project should be directed to mike.beauchene@ct.gov . This and other water related reports are available at: http://www.ct.gov/dep/cwp/view.asp?a=2719&q=487892&depNav_GID=1654

Background: 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 criteria a review of both water temperature records and fish community was conducted. Although an extensive data set exists 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 Bureau of Water Protection and Land Reuse (WPLR) point sampling data. Water temperature probes (ONSET HOBO water temp pro) were placed in stream from May-September to capture summertime temperature conditions.

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 the damming of streams by *Canor canadensis* (beaver). Some human factors include impervious surfaces, groundwater withdrawal and stream diversion, damming, and point source discharges.

WPLR and Inland Fisheries Division (IFD) have been working cooperatively to obtain hourly water temperature data using HOBO water temperature probes since 1998. As of 2011 over 1592 deployments at 565 site locations have occurred. All values are stored in a Microsoft Access database consisting of over 5.7 million data points. In addition, since 1999, we have collected 1433 fish community structure samples from 1010 locations (single pass all species). Unfortunately, until recently, each project had independent goals and objectives. Therefore much of this data set 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. Current cooperative efforts are to collect both water temperature and fish community data from the same location during the same time period.



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 for year round data recording. These same locations were electrofished during the summer 2010 to validate the presence of established populations of *Cottus cognatus* (slimy sculpin) and/or *Salvelinus fontinalis* (eastern brook trout).

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 year round and are swapped each spring and fall so to offload data, ensure the probe is functional, and remains in place per DEEP Water Temperature Monitoring Standard Operating Procedure.

Cottus cognatus (slimy sculpin) a cold water stenotherm

Summer temperature evaluation is defined as data recorded between June 1 and August 31. Typically in Connecticut, water temperature is the warmest during the months of June, July, and August. Fish community data were collecting using backpack or tote-barge electrofishing gear. All species in the sample reach are netted, measured to nearest centimeter, and released back to the stream per the WPLR Fish Community Quality Assurance Project Plan.

Beginning in 2011 water temperature data will be collected year round at these same locations for a period of at least 5 years so to capture natural climate variability. Though 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 consideration in the 2013 water quality standard review process. As water temperature is a natural component of an ecosystem and as such has variability both across space and time, the development of conventional threshold-based water quality criteria may not be as appropriate as one that can account for natural variability (Poole and others 2004).

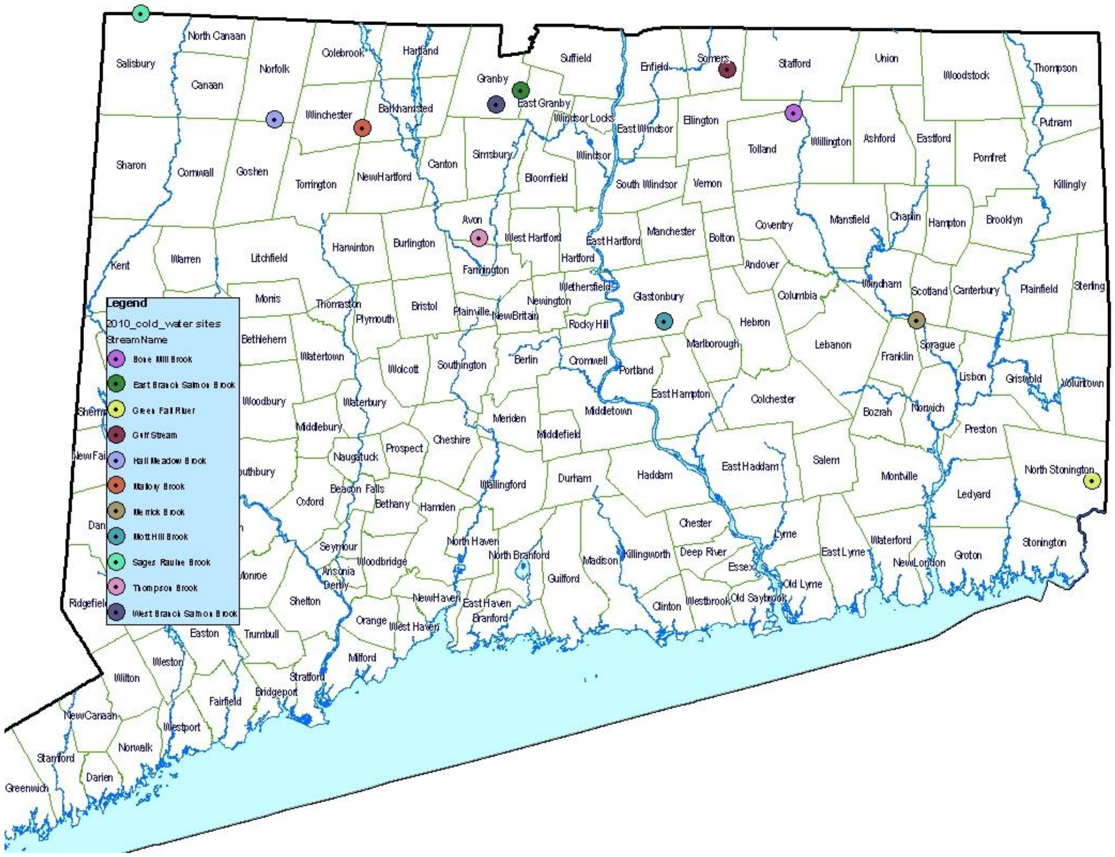


Figure 1. Location of the cold water sites selected for water temperature monitoring.

Table 1. Location information for the cold water sites selected for water temperature monitoring.

stream name	station id	proximity	Landmark	basinid	Municipality	YLat	XLong
Bone Mill Brook	1456	upstream	end of drivable 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 (2011)	780	upstream	Route 41	6001	Salisbury	42.0495	-73.4300
Sages Ravine Brook (2010)	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

General Conditions Summer 2011: 2011 was ranked as the 6th warmest year (Figure 2), which happened to follow the 4th warmest year, 2010, as determined at the Great Mountain Forest in Norfolk (http://www.greatmountainforest.org/weather/weather-by-the-month.html). It was also the wettest year on record, due to over 13" of rain during each month of August and September. Overall summer conditions could be described as slightly warmer and wetter than normal. The warmest day ever 39.4 ^{O}C (103 ^{O}F) was recorded at Bradley International Airport.

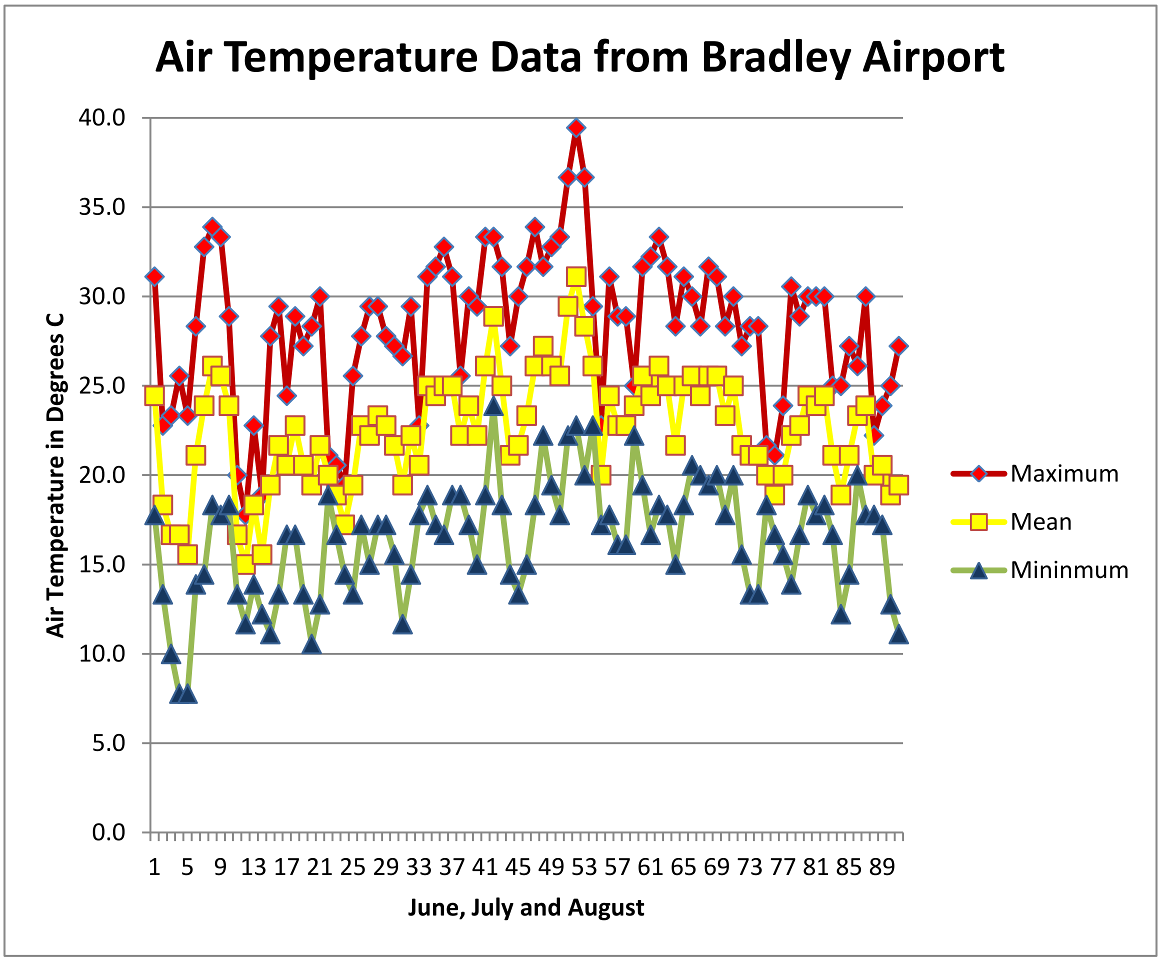


Figure 2. Plot of maximum, minimum and average air temperature recorded at Bradley International Airport during June, July, and August 2011.

Summary of data:

All sites together: 2011 was the second consecutive summer of water temperature data collection from cold water stream segments. In general it appears water temperatures at these locations were very similar with only slightly lower values for most statistics in 2011 versus 2010 (Figure 3 and Table 2). The drop in total measurements was due to the loss of two probes from the flooding following Tropical Storm *Irene* and Tropical Depression *Lee*, on August 28th and September 7-8th respectively 2010.

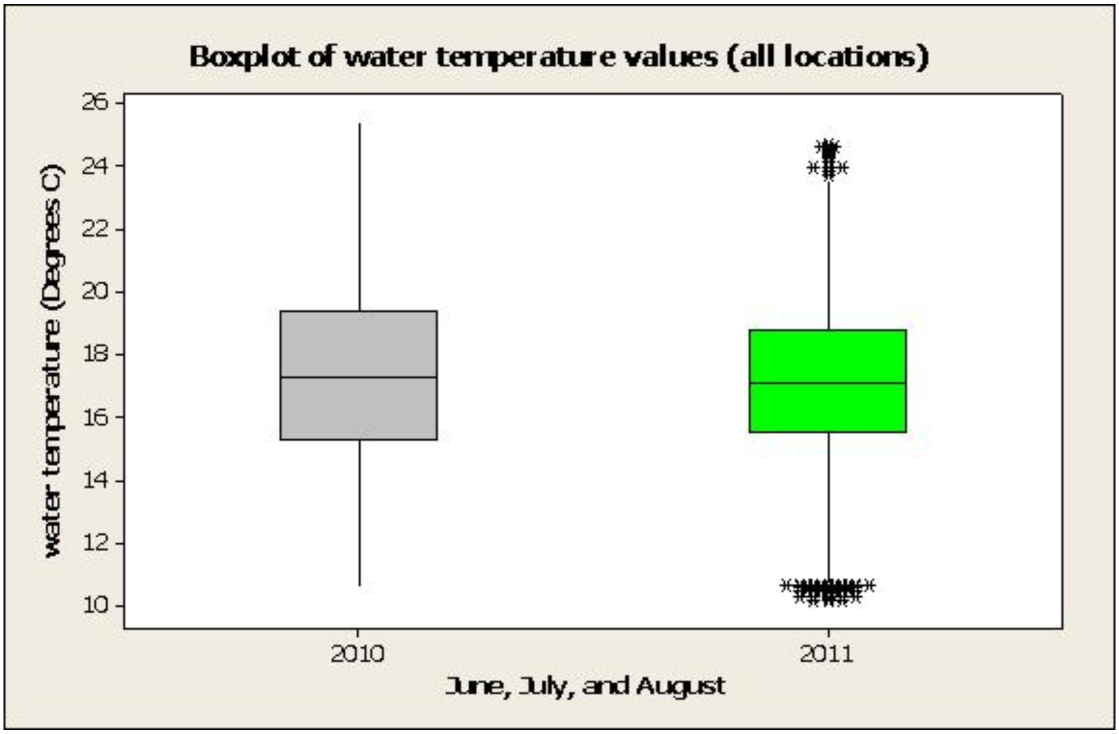


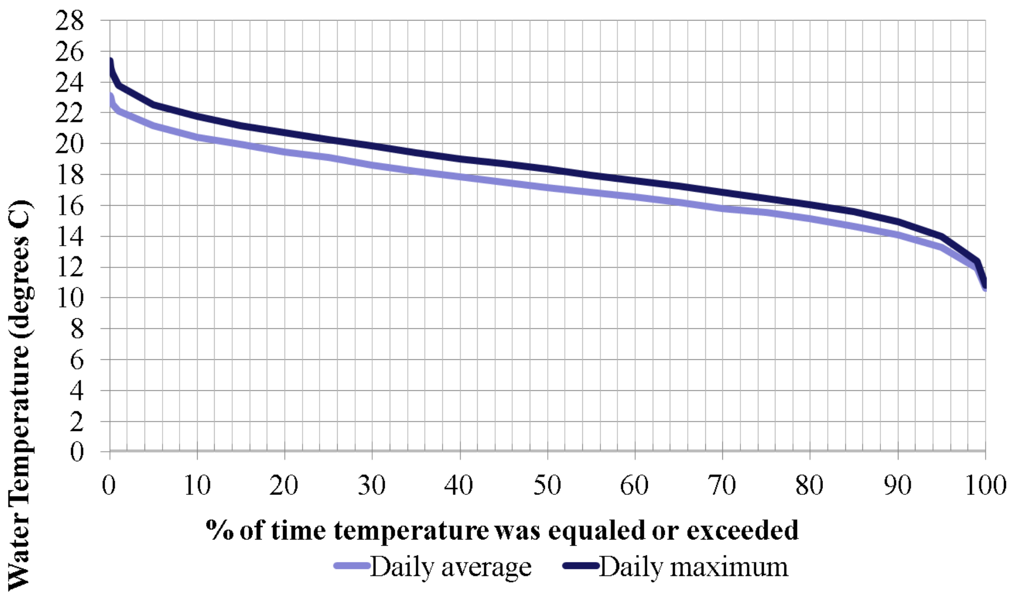
Figure 3. Box and whisker plot of all temperature values recorded from June, July, and August 2010 and 2011 from the 11 selected cold water sites.

Table 2. Select statistics for all temperature values recorded from June, July, and August 2010 and 2011 from the 11 selected cold water sites.

Statistic	year		Difference
	2010	2011	
Count	24288	19872	- 4416 (2 probes lost to flooding)
Mean	17.325	17.11	- 0.21
SE mean	0.0175	0.0162	- 0.001
StDev	2.721	2.287	- 0.34
Minimum	10.59	10.173	- 0.42
25th percentile	15.27	15.533	+ 0.26
Median	17.296	17.082	+ 0.21
75th percentile	19.389	18.771	- 0.68
Maximum	25.38	24.677	- 0.71
IQR	4.119	3.238	- 0.88

Temperature duration curves: One very informative tool to describe continuous data like water temperature is a temperature duration curve. This type of plot illustrates the, percent of time a given temperature was equaled or exceeded. The power of these plots is that they can represent very large data set and are very informative when summarizing continuous data. One traditional application has been to display stream flow data in a flow duration curve. Decade's worth of measurements can viewed on one concise plot allowing the user to gain an understanding of the relationship between the variable being measured and the location of the measurement.

The water temperature data from the cold water stations collected during summer 2010 and summer 2011 were combined are represented in the plot below (Figure 4). The upper line represents the average daily maximum and the lower line the average daily mean temperatures for all stations over the 2 summers (44,160 individual water temperature data points). From this plot it can be determined at what frequency during June, July, and August water temperature could be at or above/below a particular value. For example 50% of the average daily maximum temperatures are at or above 18.4 ^{O}C.



	% of time water temperature is equal to or warmer than				
temperature category- daily statistic	**5**	**25**	**50**	**75**	**95**
cold water- daily maximum	22.5	20.3	18.4	16.5	14
cold water- daily average	21.2	19.1	17.2	15.5	13.3

Figure 4. Average daily maximum and mean water temperature exceedance curves and percentiles for data collected both summer 2010 and 2011 at the 11 cold water stations.

All cold water sites individually: Median values for all sites in 2011 were either close to or below those for 2010, except for Mott Hill Brook and Thompson Brook (Figure 5 and Table 3). Variability is expected with both space and time as water temperature is a natural variable. Healthy ecosystems and their biological communities are expecting and or requiring natural variability. A goal of this project, characterizing cold water fish habitat, is to understand this natural variability so that it can be used to inform the water quality standard decision making process. Over the two consecutive summers, the standard deviation about the mean is 1.7 and the median 1.6 degrees C (Table 3a).

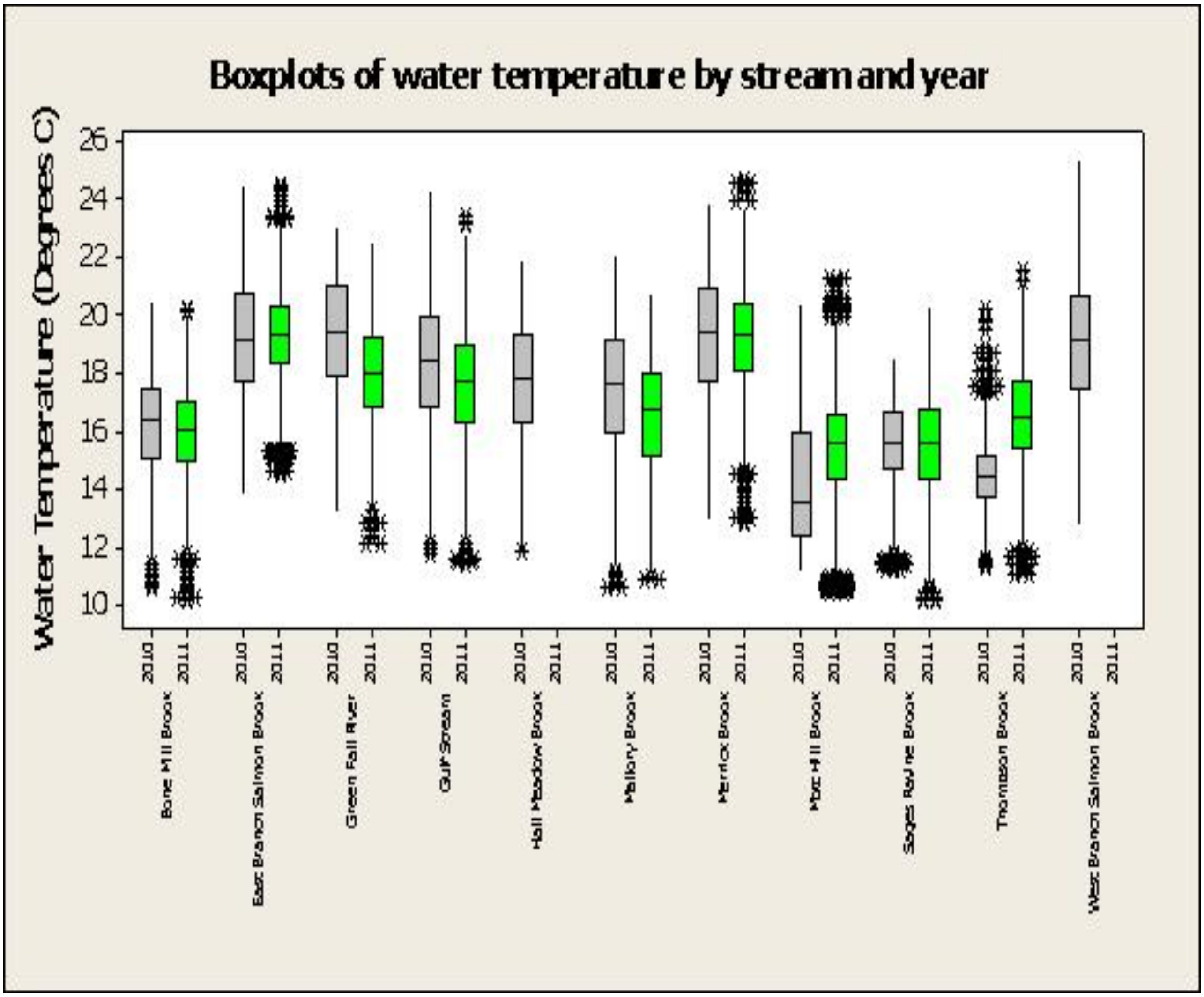


Figure 5. Box plot by station and year for all temperature values recorded from June, July, and August 2010 and 2011 from the 11 selected cold water sites. The two missing plots, Hall Meadow and West Branch Salmon Brook, were lost to flooding.

Table 3. Select statistics by station for all temperature values recorded from June, July, and August 2010 and 2011 from the 11 selected cold water sites.

Stream	year	Mean	STD Dev	Min	Median	25th percentile	75th percentile	Max	Range
Bonemill Brook	2011	15.9	1.6	10.2	14.9	16.0	17.0	20.2	10.0
	2010	16.2	1.8	10.6	15.1	16.4	17.5	20.5	9.9
East Branch Salmon Brook	2011	19.3	1.7	14.5	18.3	19.4	20.3	24.6	10.0
	2010	19.2	2.0	13.8	17.8	19.2	20.7	24.5	10.7
Green Fall River	2011	18.0	1.8	12.1	16.8	18.0	19.2	22.5	10.4
	2010	19.3	2.1	13.2	17.9	19.4	21.0	23.1	9.9
Gulf Stream	2011	17.6	1.9	11.4	16.3	17.8	19.0	23.5	12.0
	2010	18.2	2.3	11.7	16.8	18.4	19.9	24.4	12.6
Hall Meadow Brook	2011	**lost**							
	2010	17.7	2.0	11.8	16.3	17.8	19.3	21.9	10.1
Mallory Brook	2011	16.5	1.9	10.8	15.2	16.7	18.0	20.8	9.9
	2010	17.4	2.3	10.6	16.0	17.7	19.1	22.1	11.5
Merrick Brook	2011	19.2	1.9	12.8	18.1	19.4	20.4	24.7	11.8
	2010	19.2	2.2	12.9	17.7	19.5	21.0	23.9	10.9
Mott Hill Brook	2011	15.5	2.0	10.4	14.4	15.6	16.6	21.3	10.8
	2010	14.2	2.1	11.2	12.4	13.5	15.9	20.4	9.2
Sages Ravine Brook	2011	15.5	1.8	10.2	14.3	15.6	16.8	20.3	10.1
	2010	15.5	1.4	11.2	14.7	15.6	16.7	18.6	7.3
Thompson Brook	2011	16.5	1.7	11.0	15.4	16.5	17.7	21.6	10.6
	2010	14.5	1.1	11.3	13.7	14.4	15.2	20.2	8.9
West Branch Salmon Brook	2011	**lost**							
	2010	19.1	2.4	12.7	17.5	19.2	20.7	25.4	12.7

Table 3a. Summary statistics for the measured statistics from summer 2010 at the 11 cold water stations.

	Mean	STD Dev	Minimum	Median	25th percentile	75th percentile	Maximum
mean	17.2	1.9	11.7	16.0	17.3	18.6	22.2
st dev	1.7	0.3	1.2	1.6	1.8	1.8	1.9
min	14.2	1.1	10.2	12.4	13.5	15.2	18.6
max	19.3	2.4	14.5	18.3	19.5	21.0	25.4
median	17.5	1.9	11.4	16.1	17.7	19.1	22.0

Unlike 2010 where the July temperatures were higher than August temperatures at the majority of cold water sites, July and August temperatures were similar to each other in 2011 (Figure 6 and Table 4). The distribution of temperature was more even in 2011 than in 2010 when both Sages Ravine Brook and Thompson Brook had the majority of the August values in a very narrow temperature range. In general June values appear to be cooler in 2011 than they were in 2010 (Figure 7).

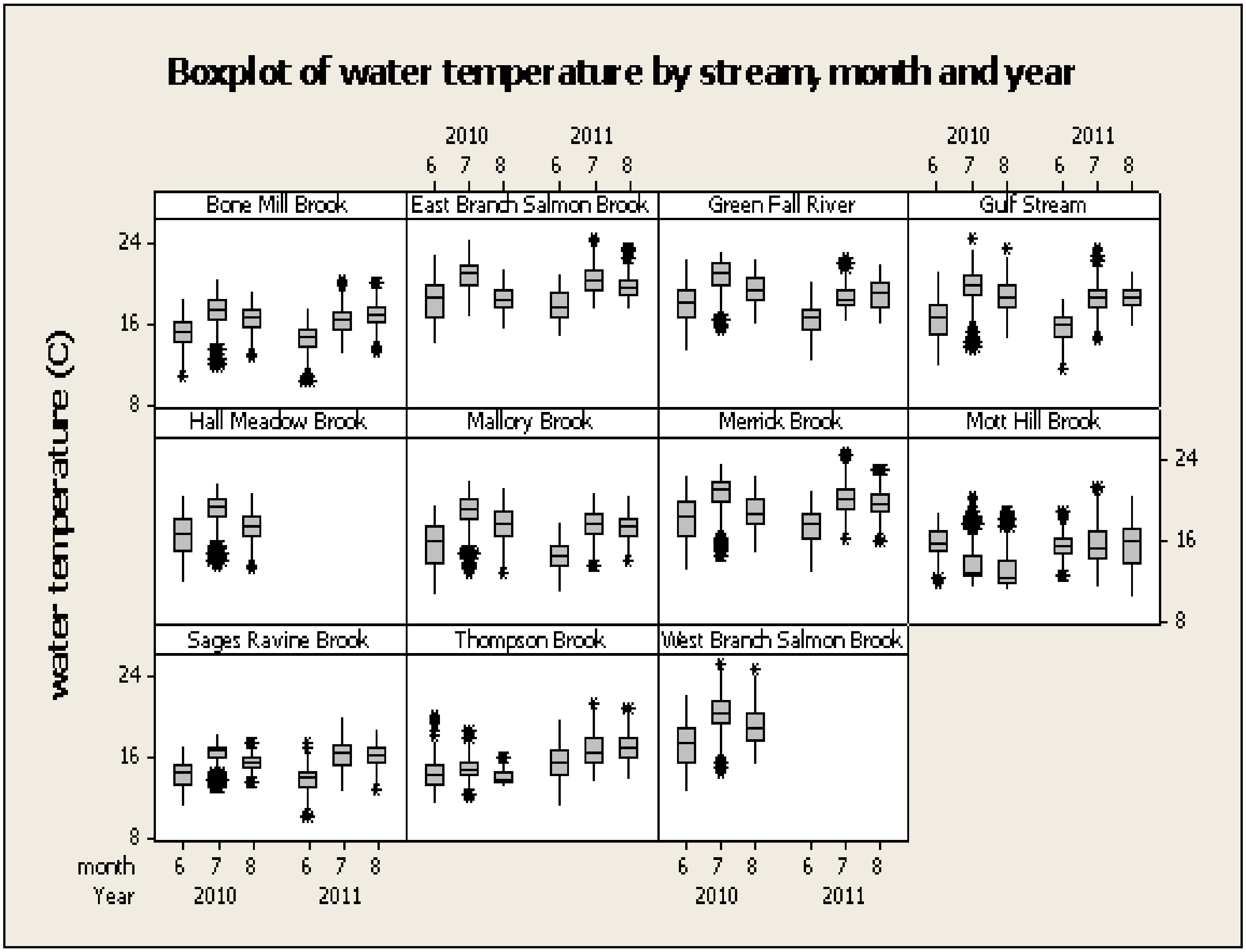


Figure 6. Box and whisker plot of all temperature values recorded by site and by month for each of the 11 cold water stations June, July, and August 2010 and 2011. The probe was lost at the Hall Meadow and West Branch Salmon Brook locations due to flooding.

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 and 2011. The probe was lost at the Hall Meadow and West Branch Salmon Brook locations due to flooding.

Stream	month	year	mean	StDev	Q1	Median	Q3	Minimum	Maximum	Range
Bone Mill Brook	6	2011	14.5	1.4	13.7	14.7	15.4	10.2	17.5	7.4
Bone Mill Brook	6	2010	15.0	1.5	14.0	15.1	16.1	10.6	18.7	8.0
Bone Mill Brook	7	2011	16.3	1.3	15.4	16.4	17.1	12.9	20.2	7.3
Bone Mill Brook	7	2010	17.2	1.7	16.4	17.4	18.4	11.7	20.5	8.8
Bone Mill Brook	8	2011	16.9	1.2	16.0	16.9	17.6	13.2	20.0	6.8
Bone Mill Brook	8	2010	16.5	1.3	15.6	16.5	17.3	12.5	19.3	6.8
East Branch Salmon Brook	6	2011	17.8	1.5	16.6	17.6	19.0	14.5	21.1	6.6
East Branch Salmon Brook	6	2010	18.4	2.1	16.6	18.7	19.9	13.8	22.9	9.1
East Branch Salmon Brook	7	2011	20.3	1.3	19.2	20.2	21.2	17.4	24.6	7.2
East Branch Salmon Brook	7	2010	20.7	1.6	19.7	20.9	21.7	16.7	24.5	7.9
East Branch Salmon Brook	8	2011	19.7	1.2	18.9	19.7	20.4	17.2	23.4	6.2
East Branch Salmon Brook	8	2010	18.5	1.3	17.5	18.4	19.4	15.4	21.4	6.0
Green Fall River	6	2011	16.4	1.5	15.3	16.5	17.4	12.1	20.2	8.1
Green Fall River	6	2010	17.8	2.1	16.5	17.9	19.4	13.2	22.5	9.3
Green Fall River	7	2011	18.6	1.3	17.7	18.3	19.2	16.0	22.5	6.5
Green Fall River	7	2010	20.7	1.7	19.8	21.1	21.9	15.5	23.1	7.7
Green Fall River	8	2011	18.8	1.4	17.7	19.1	20.0	15.8	21.9	6.1
Green Fall River	8	2010	19.3	1.4	18.3	19.2	20.4	15.9	22.5	6.6
Gulf Stream	6	2011	15.6	1.5	14.6	15.7	16.6	11.4	18.5	7.1
Gulf Stream	6	2010	16.4	1.9	14.9	16.6	17.8	11.7	21.2	9.5
Gulf Stream	7	2011	18.5	1.5	17.5	18.6	19.4	14.2	23.5	9.2
Gulf Stream	7	2010	19.6	2.0	18.7	19.8	20.8	13.3	24.4	11.1
Gulf Stream	8	2011	18.5	1.1	17.7	18.5	19.3	15.5	21.3	5.8
Gulf Stream	8	2010	18.7	1.6	17.5	18.6	19.9	14.3	23.5	9.2
Hall Meadow Brook	6	2011								
Hall Meadow Brook	6	2010	16.6	2.0	15.1	16.8	18.3	11.8	20.7	8.8
Hall Meadow Brook	7	2011								
Hall Meadow Brook	7	2010	19.0	1.8	18.3	19.5	20.2	13.6	21.9	8.3
Hall Meadow Brook	8	2011								
Hall Meadow Brook	8	2010	17.5	1.5	16.6	17.4	18.5	13.3	20.8	7.5
Mallory Brook	6	2011	14.6	1.3	13.6	14.6	15.4	10.8	18.0	7.2
Mallory Brook	6	2010	15.7	2.1	13.8	16.0	17.4	10.6	19.5	8.9
Mallory Brook	7	2011	17.7	1.5	16.7	17.8	18.7	13.5	20.8	7.3
Mallory Brook	7	2010	18.8	1.9	18.1	19.3	20.0	12.9	22.1	9.2
Mallory Brook	8	2011	17.3	1.2	16.5	17.3	18.2	14.0	20.7	6.6
Mallory Brook	8	2010	17.6	1.7	16.4	17.6	18.8	12.8	21.3	8.5
Merrick Brook	6	2011	17.5	1.7	16.2	17.6	18.8	12.8	21.1	8.3
Merrick Brook	6	2010	18.1	2.2	16.4	18.4	20.0	12.9	22.6	9.6
Merrick Brook	7	2011	20.2	1.4	19.2	20.1	21.2	16.3	24.7	8.3
Merrick Brook	7	2010	20.6	1.9	19.8	21.1	21.9	14.4	23.9	9.5
Merrick Brook	8	2011	19.7	1.3	18.9	19.7	20.5	16.1	23.1	7.0
Merrick Brook	8	2010	18.9	1.6	17.7	18.7	20.1	14.7	22.6	7.9
Mott Hill Brook	6	2011	15.5	1.1	14.8	15.6	16.2	12.5	18.8	6.4

Mott Hill Brook	6	2010	15.9	1.5	15.1	15.8	16.9	11.9	18.9	7.0
Mott Hill Brook	7	2011	15.5	2.1	14.3	15.2	17.0	11.3	21.3	10.0
Mott Hill Brook	7	2010	13.6	1.7	12.6	12.9	14.4	11.4	20.4	8.9
Mott Hill Brook	8	2011	15.5	2.6	13.8	15.9	17.2	10.4	20.6	10.2
Mott Hill Brook	8	2010	13.2	2.0	11.8	12.2	14.1	11.2	19.0	7.9
Sages Ravine Brook	6	2011	13.9	1.4	13.0	14.1	14.7	10.2	17.7	7.5
Sages Ravine Brook	6	2010	14.3	1.4	13.4	14.6	15.3	11.2	17.2	6.0
Sages Ravine Brook	7	2011	16.4	1.6	15.2	16.5	17.4	12.5	20.3	7.8
Sages Ravine Brook	7	2010	16.4	1.2	16.2	16.8	17.2	13.0	18.6	5.5
Sages Ravine Brook	8	2011	16.2	1.2	15.5	16.3	17.1	12.8	19.0	6.2
Sages Ravine Brook	8	2010	15.6	0.7	15.2	15.6	16.1	13.5	17.6	4.0
Thompson Brook	6	2011	15.5	1.7	14.4	15.6	16.7	11.0	20.0	9.0
Thompson Brook	6	2010	14.4	1.4	13.4	14.3	15.2	11.3	20.2	8.9
Thompson Brook	7	2011	16.8	1.5	15.7	16.6	18.0	13.6	21.6	8.0
Thompson Brook	7	2010	15.0	1.0	14.3	14.9	15.7	12.1	18.7	6.6
Thompson Brook	8	2011	17.3	1.4	16.2	17.2	18.1	13.9	21.1	7.2
Thompson Brook	8	2010	14.1	0.6	13.7	13.9	14.6	13.2	16.1	2.9
West Branch Salmon Brook	6	2011								
West Branch Salmon Brook	6	2010	17.4	2.2	15.5	17.5	19.0	12.7	22.5	9.8
West Branch Salmon Brook	7	2011								
West Branch Salmon Brook	7	2010	20.5	1.9	19.4	20.6	21.8	14.7	25.4	10.7
West Branch Salmon Brook	8	2011								
West Branch Salmon Brook	8	2010	19.2	1.8	17.8	19.0	20.5	15.3	25.0	9.7

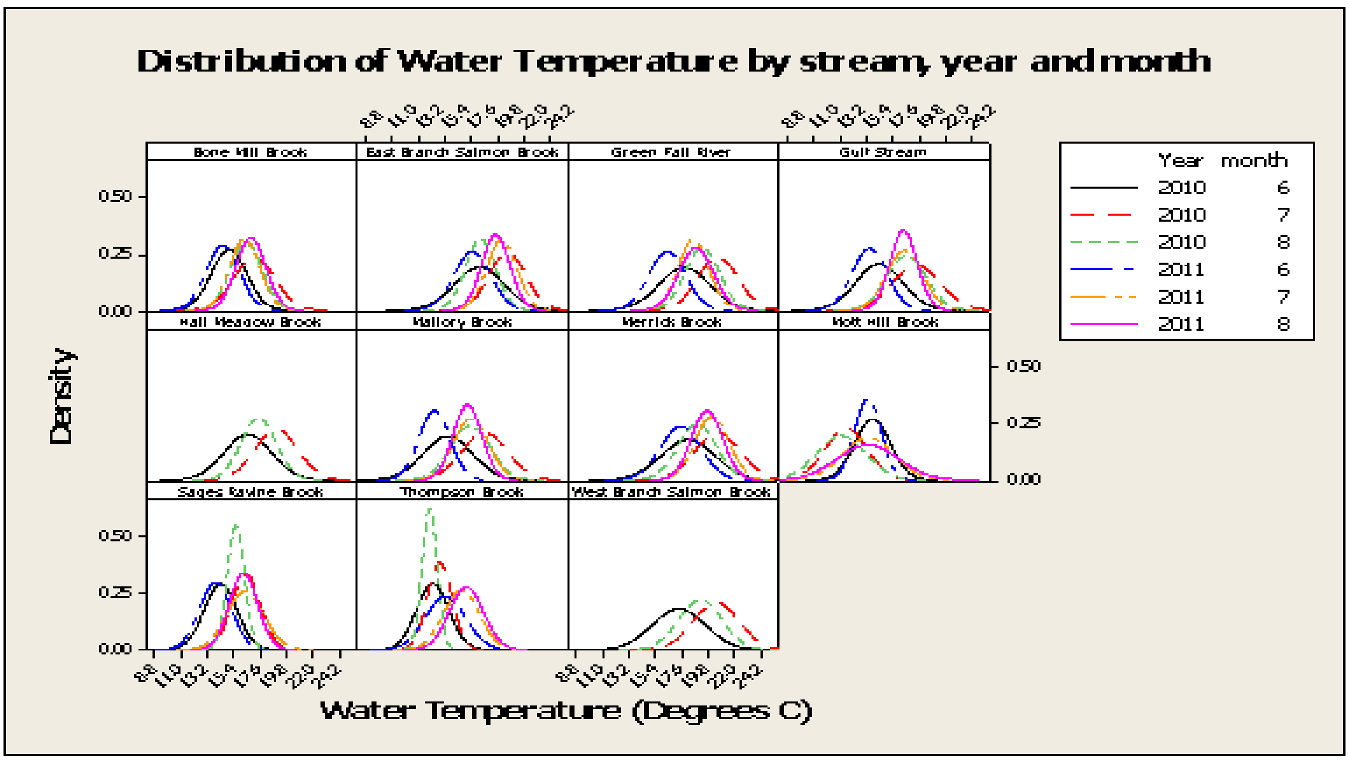


Figure 7. Histograms of water temperature data by site and by month for the 11 cold water sites June, July and August 2010.

Individual value plot (Figure 8) illustrates how each data point is distributed for each location for both 2010 and 2011. The majority of observations were in the similar range for both 2010 and 2011 data.

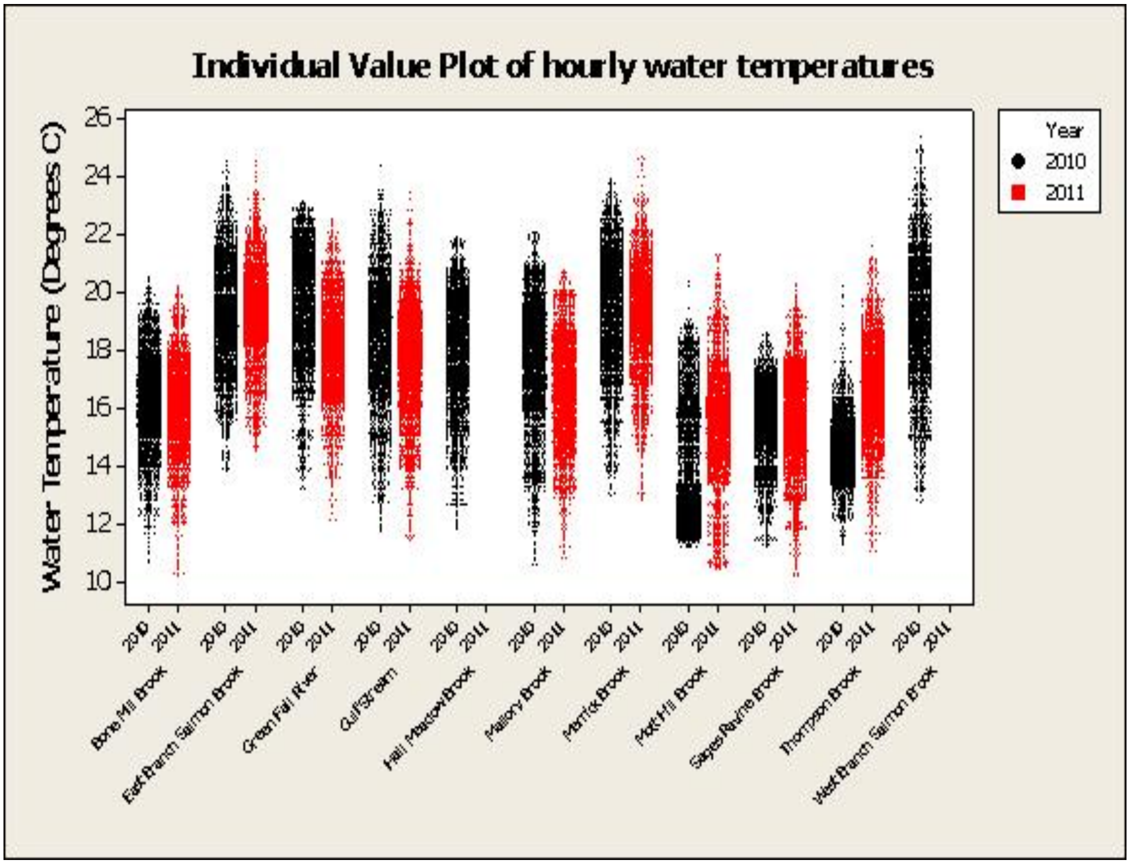


Figure 8. Individual dot plots for water temperature data by site and year for the 11 cold water sites during June, July and August 2010 (black) and 2011 (red).

Cold water sites compared to other locations: Both WPLR and IFD deploy water temperature probes in locations other than cold water streams for a variety of programmatic goals and objectives. The box plot in Figure 9 illustrates how the 11 cold water stations have very different water temperatures than those of selected warm water habitat.

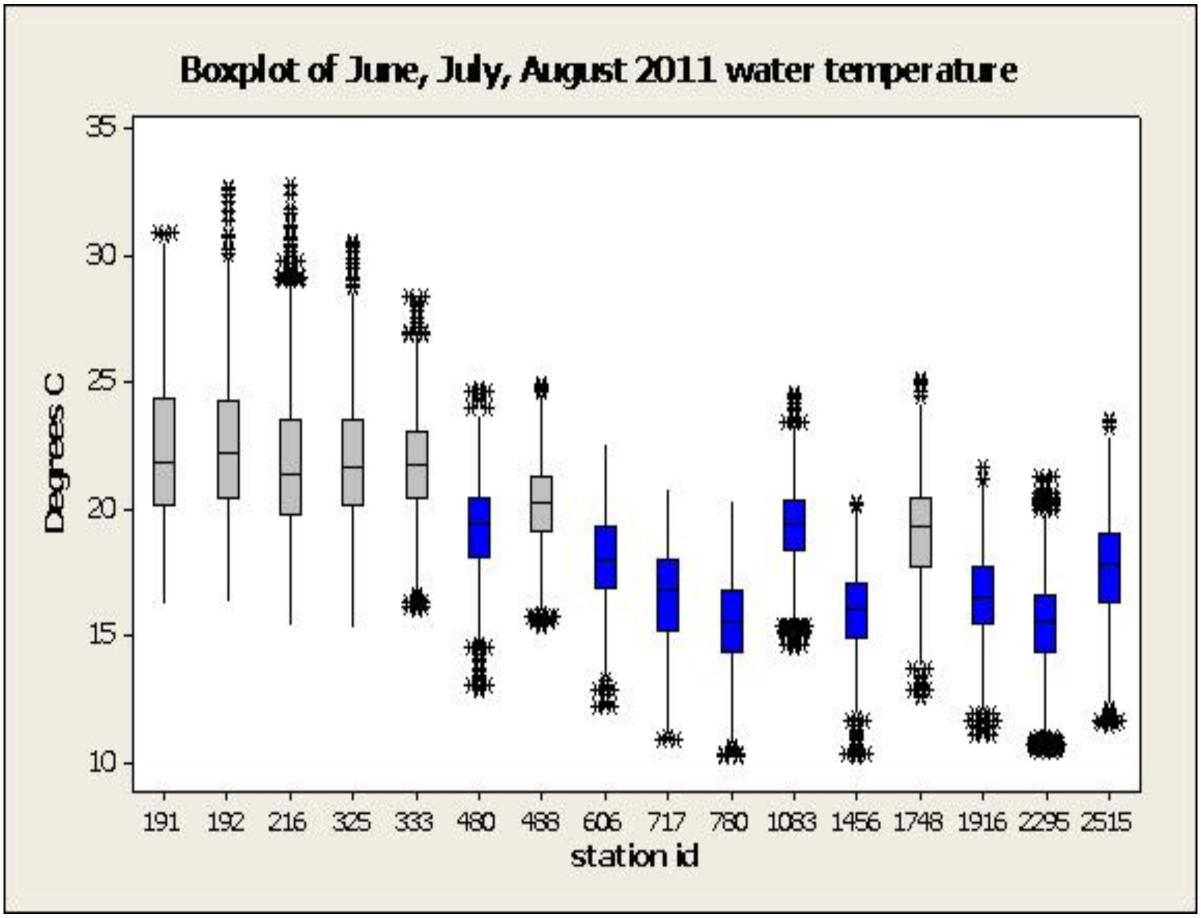
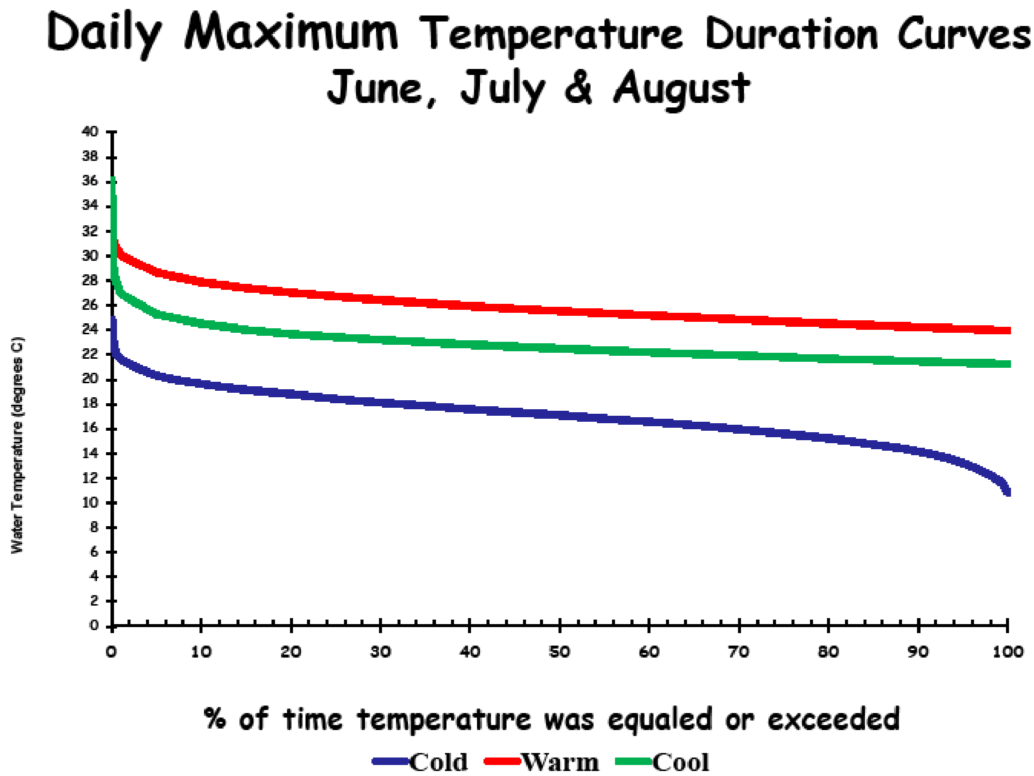


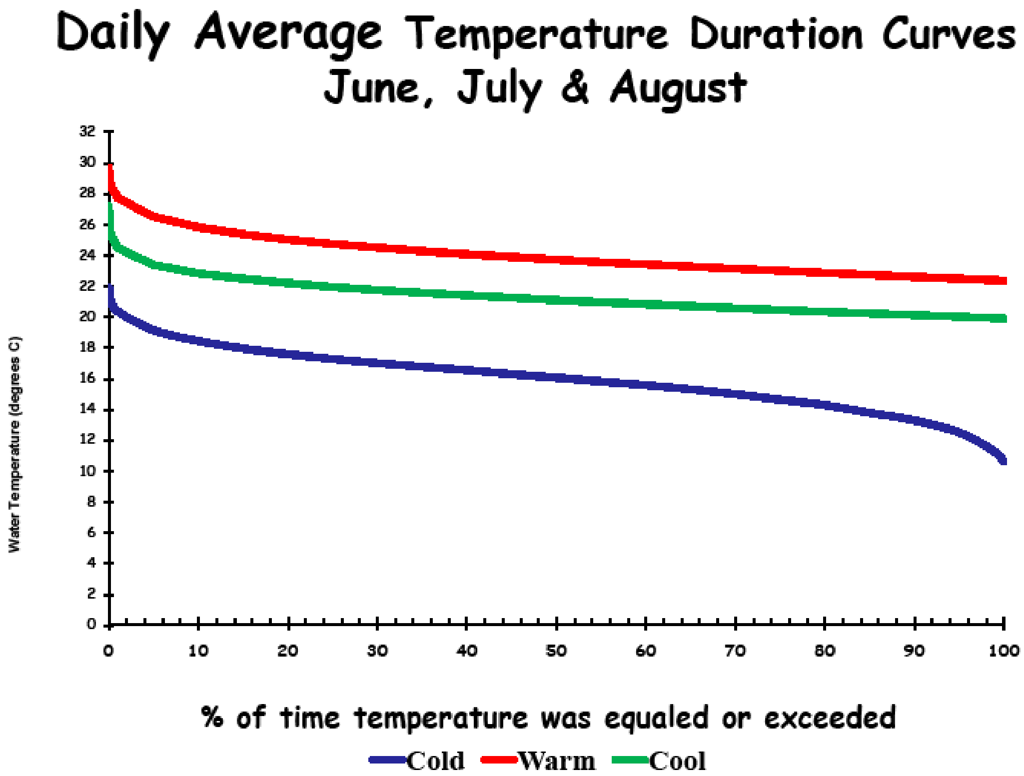
Figure 9. Box and whisker plots of water temperature data for selected long-term water temperature monitoring sites (grey boxes) and the cold water sites (blue boxes) for June, July, and August 2011. Probes at Hall Meadow Brook and West Branch Salmon Brook were lost due to flooding.

When the temperature duration curves are generated for all of the water temperature data contained within the HOBO central database they allow a user to draw strong conclusions about summer water temperatures in cold, cool and warm water habitats. Figure 10 and Figure 11 are plots of average daily maximum and the average daily mean water temperature respectively. All three habitat types, cold, cool, and warm, are clearly defined and different from each other with the exception being overlap between the maximum average daily maximum values of cool and warm streams (frequency < 1%).



			% of time water temperature is equal to or warmer than				
	Stations	**Observations**	**5**	**25**	**50**	**75**	**95**
all cold in data set -Daily Max	33	3650	20.4	18.4	17.1	15.6	13.2
all cool in data set -Daily Max	279	42924	25.3	23.4	22.5	21.8	21.3
all warm in data set -Daily Max	214	42930	28.7	26.7	25.6	24.7	24.1

Figure 10. Average daily maximum water temperature exceedance curves and statistics for stations classified as cold water habitat, cool water habitat, and warm water habitat as defined by thresholds in Lyons and others 2009.



			% of time water temperature is equal to or warmer than				
Statistic	**Stations**	**Observations**	**5**	**25**	**50**	**75**	**95**
all cold in data set - Daily Average	33	3650	19.2	17.3	16.1	14.6	12.5
all cool in data set - Daily Average	279	42924	23.4	22.0	21.1	20.5	20.0
all warm in data set - Daily Average	214	42930	26.5	24.8	23.7	23.0	22.5

Figure 11. Average daily mean water temperature exceedance curves and statistics for stations classified as cold water habitat, cool water habitat, and warm water habitat as defined by thresholds in Lyons and others 2009.

When all 33 of the sites considered to be cold water habitat are compared one can see the variability around the continuous water temperature data for cold water habitats (Figure 12 and Table 5). The variance around the mean maximum daily temperature line can be informative when developing regime-based water quality criteria that are more appropriate than traditional threshold-based values (Poole and others 2004).

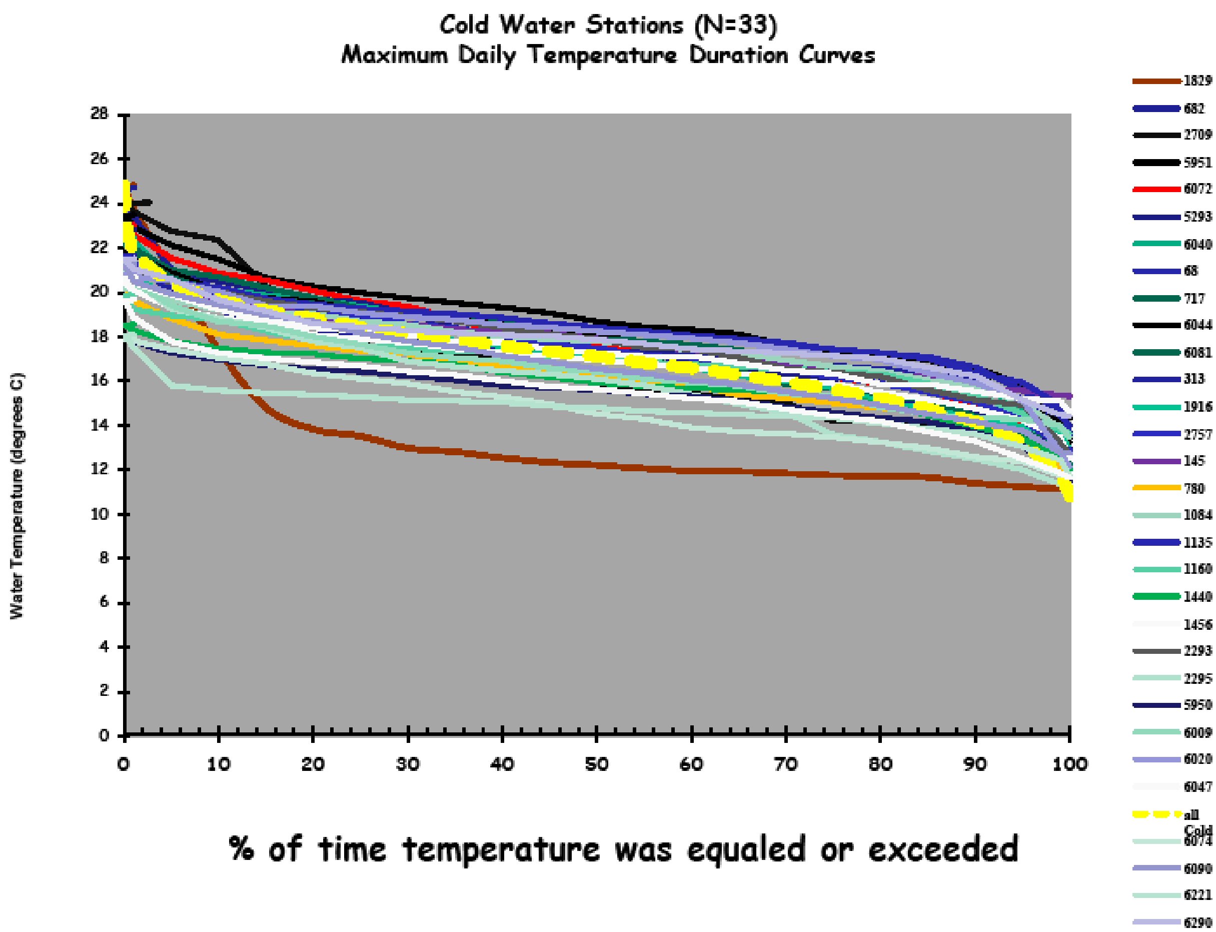


Figure 12. Average daily maximum water temperature exceedance curves for 33 locations classified as cold water habitat based on measured water temperature data and thresholds described in Lyons and others 2009. The yellow dashed line represents the curve for all 33 locations combined.

Table 5. Percentiles for the average daily maximum water temperature exceedance curves for 33 locations classified as cold water habitat based on measured water temperature data and Lyons 2009 thresholds (Table 12). The yellow dashed line represents the curve for all 33 locations combined.

	% of time water temperature is equal to or warmer than				
station id	*5th*	*25th*	*50th*	*75th*	*95th*
All 33 sites	***20.4***	***18.4***	***17.1***	***15.6***	***13.2***
1829	*20.9*	*13.5*	*12.2*	*11.8*	*11.2*
682	*21.0*	*18.7*	*17.5*	*16.5*	*15.1*
2709	*22.8*	*17.7*	*15.8*	*14.2*	*13.8*
5951	*22.1*	*20.0*	*18.7*	*17.4*	*15.8*
6072	*21.5*	*19.6*	*17.7*	*16.2*	*13.9*
5293	*20.8*	*19.5*	*17.4*	*15.9*	*13.7*
6040	*20.6*	*19.4*	*18.1*	*16.6*	*14.8*
68	*20.9*	*19.3*	*18.4*	*17.4*	*15.6*
717	*21.0*	*19.3*	*18.0*	*16.5*	*13.8*
6044	*20.9*	*19.1*	*18.1*	*17.3*	*15.0*
6081	*20.7*	*19.0*	*17.1*	*15.6*	*13.5*
313	*20.1*	*18.0*	*17.4*	*16.7*	*15.2*
1916	*19.8*	*18.3*	*17.0*	*15.7*	*13.9*
2757	*20.4*	*19.0*	*17.5*	*16.2*	*14.2*
145	*19.9*	*18.6*	*17.9*	*16.6*	*15.6*
780	*18.8*	*17.4*	*16.2*	*15.0*	*13.4*
1084	*19.7*	*18.7*	*17.8*	*16.7*	*15.0*
1135	*20.4*	*19.3*	*18.4*	*17.4*	*15.9*
1160	*18.9*	*17.6*	*17.0*	*16.4*	*14.5*
1440	*17.8*	*17.0*	*15.9*	*15.2*	*13.4*
1456	*19.3*	*17.9*	*16.9*	*15.9*	*14.2*
2293	*20.4*	*19.1*	*17.9*	*16.4*	*14.9*
2295	*19.2*	*17.5*	*16.1*	*13.6*	*12.0*
5950	*17.3*	*16.4*	*15.6*	*14.6*	*13.1*
6009	*19.4*	*17.7*	*16.4*	*15.3*	*14.3*
6020	*20.5*	*19.1*	*18.2*	*17.1*	*15.1*
6047	*19.9*	*18.2*	*17.3*	*16.3*	*15.2*
6074	*17.4*	*16.1*	*14.5*	*13.5*	*12.4*
6079	*19.9*	*18.2*	*16.5*	*15.2*	*13.8*
6090	*19.4*	*17.1*	*16.3*	*15.4*	*12.5*
6221	*15.8*	*15.3*	*14.8*	*14.3*	*13.0*
6290	*20.6*	*18.4*	*17.9*	*17.1*	*15.2*
6295	*17.8*	*16.7*	*15.6*	*14.4*	*12.5*

Water temperature monitoring in Connecticut: WPLR and IFD have been working cooperatively to obtain hourly water temperature data using HOBO water temperature probes since 1998. As of 2011 over 1592 deployments at 565 site locations have occurred all values are stored in a Microsoft Access database consisting of over 5.7 million data points. Using thresholds described in Lyons and others 2009 (Table 6), we have been able to categorize each deployment at each location (Figure 12). We are then able to take a mean or median value to determine the habitat type at each site location (Figure 13).

Table 6. Water temperature thresholds for three habitat types described by Lyons and others 2009.

Water Temperature Category	Maximum Daily Temperature °C (°F)	July Mean Temperature °C (°F)	Mean Summer Temperature °C (°F) Summer = June, July, August
Cold	< 20 (68 °F)	< 17.5 (63.5 °F)	< 18 (64.4 °F)
Cool	20-24 (68-75.2°F)	17.5-21.0 (63.5-69.8 °F)	18-21 (64.4-69.8° F)
Warm	>24 (75.2 °F)	>21.0 (69.8 °F)	21-24 (68.8- 75.2 °F)

Station ID	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Median of years
6210													4		4
5950											1				1
5951											1				1
6072												1			1
2480										2					2
1304											3	3	3	3	3
2481														3	3
1											4	3	4	4	4
6287														4	4
5952					4										4
5953					4										4
915														4	4
5954					4	4						4	4	4	4
4									2						2
518				2	2										2

Figure 12. An excerpt from a summary spreadsheet that contains the Lyons and others 2009 classification of real-world water temperature data measured at stations across Connecticut. 1= cold, 2 = cool-cold transition, 3= cool-warm transition, and 4 = warm water habitat. This type of approach allows to organize and evaluate large data sets in a very easy to interpret format. The median or mean value can be used to classify the site if a single description is necessary (Figure 13).

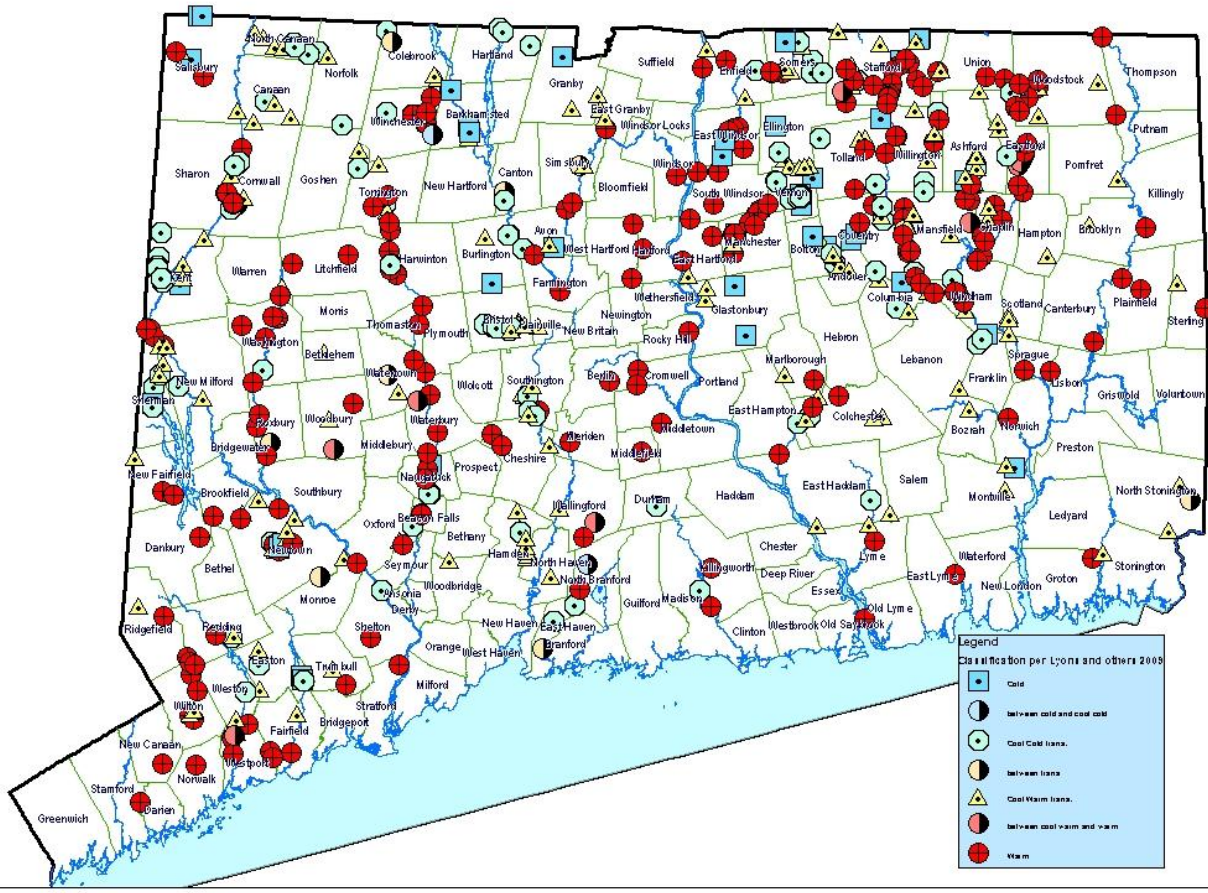


Figure 13. Water temperature habitat classification based upon measured HOBO water temperature data from both IFD and WPLR from 1998-2011. Determination of classification was based upon ranges presented in Lyons and others 2009. As of 2011 over 1592 deployments at 565 site locations have occurred all values are stored in a Microsoft Access database consisting of over 5.7 million data points.

References

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.

Poole, G., Dunham, J., Keenan, D., Sauter, S., McCullough, D., Mebane, C., Lockwood, J., Essig, D., Hicks, M., Sturdevant, D., Materna, E., Spalding, S., Risley, J., and Deppman, M. 2004. *The Case for Regime-Based Water Quality Standards*. BioScience, Vol. 54, Number 2, 155-161.