AMBIENT MONITORING AND ASSESSMENT PROGRAM

CORE ELEMENT SUMMARY REPORT FOR INLAND WATERS

2006-2010

Connecticut Department of ENERGY & ENVIRONMENTAL PROTECTION

Bureau of Water Protection & Land Reuse

Planning and Standards Division
79 Elm Street
Hartford, CT 06106

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Cover:

Water quality data provide the foundation management of Connecticut's river and stream resources. It is the charge of the ambient monitoring program to develop and implement monitoring strategies that result in the collection and analysis of physical, chemical, and biological data forming this foundation. Staff within this program work cooperatively with many internal and external partners to insure that sufficient credible water quality data are available to make the most informed management decisions so to insure a high-quality resource for generations to come.

Photo credits:

All photographs contained in this report were taken by CT DEEP WPLR Monitoring and Assessment program staff with the exception of the following; Brian Duffy, NY DEC, Hydropsychid caddis (cover), and all macroinvertebrates on page 16. Robert Jacobs, CT DEEP Inland Fisheries, coolwater fish examples and brown bullhead (p. 37) and all crayfish (p. 38).

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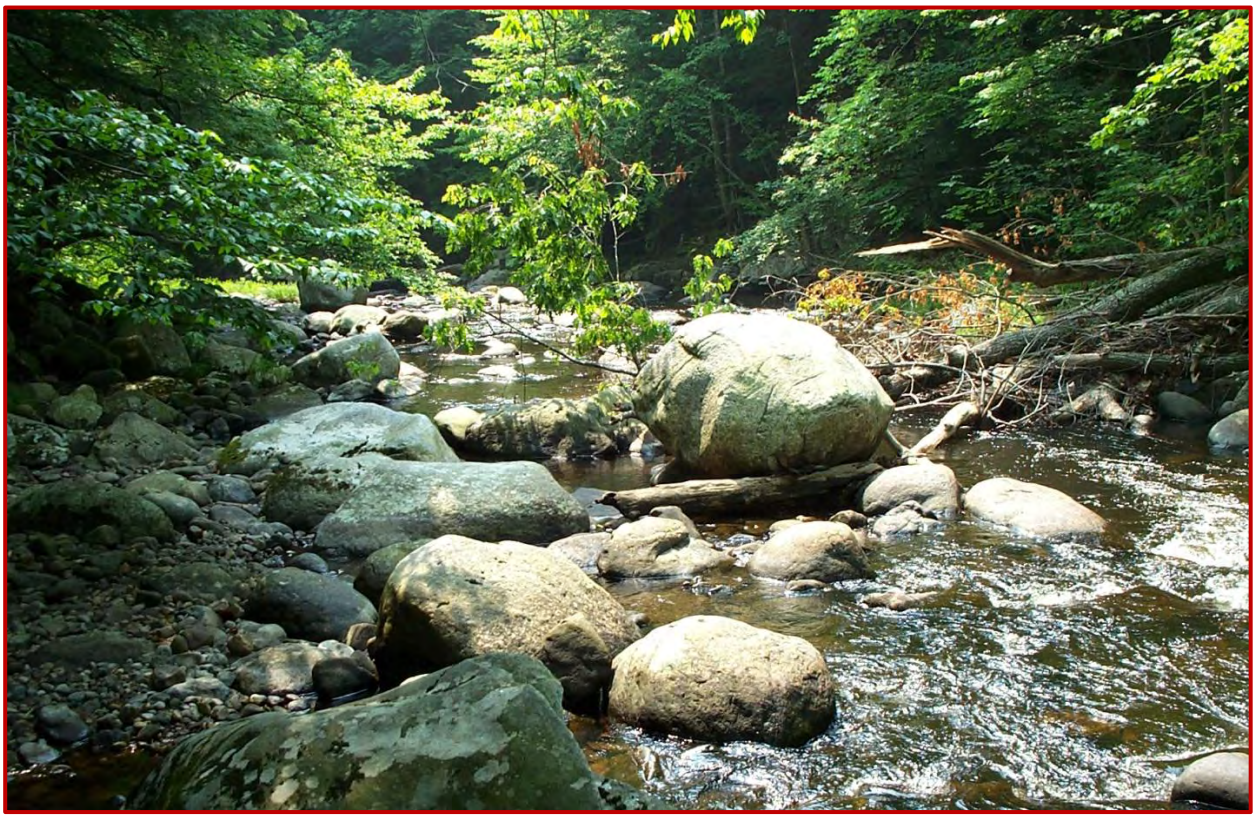
Acronyms used in this report

Abbreviation	Acronym
ALUS	Aquatic Life Use Support
AWQ	Ambient Water Quality
BCG	Biological Condition Gradient
CALM	Consolidated Assessment and Listing Methodology
CFU	Colony forming unit
CT DPH	Connecticut Department of Public Health
CW MMI	Cold Water Multi-Metric Index
CWA	Clean Water Act
DEEP	Department of Energy and Environmental Protection
FDA	Food and Drug Administration
GRTS	Generalized Random Tessellation Stratified survey design
HUC	Hydrologic Unit Code
IC	Impervious cover
IWQR	Integrated Water Quality Report
LIS	Long Island Sound
MBI	Midwest Biological Institute
MMI	Multi-Metric Index
MW MMI	Mixed Water Multi-Metric Index
NEAEB	New England Association of Environmental Biologists
NELP	New England Lakes and Ponds
NEWS	New England Wadeable Stream project
NLA	National Lakes Assessment
NRSA	National Rivers and Streams Assessment
RBV	Rapid Bioassessment by Volunteers
REMAP	Regional Environmental Monitoring and Assessment Program
TMDL	Total Maximum Daily Load
UConn CESE	University of Connecticut Center for Environmental Sciences and Engineering
USDA	United States Department of Agriculture
US EPA	Unites States Environmental Protection Agency
USGS	United States Geological Survey
WPLR	Water Protection and Land Reuse
WQS	Water Quality Standards
WQX	Water Quality Exchange

Summary

This report provides a summary of various types of water quality monitoring data (physical, chemical, and biological) that was collected between 2006-2010 primarily by the Connecticut Department of Energy and Environmental Protection (DEEP), Bureau of Water Protection and Land Reuse (WPLR), but also includes data collected by the DEEP Inland Fisheries Division, citizen-based monitoring programs, academic institutions, and other sources.

To fulfill obligations under the Federal Clean Water Act (CWA), particularly Sections 305 (b) and Sections 303 (d), DEEP submits the Integrated Water Quality Report (IWQR) to the United States Environmental Protection Agency (US EPA) every two years. The IWQR contains the "final assessment" for many different designated uses of Connecticut's aquatic resources but does not contain any specific detail about the data behind these assessments. The purpose of this report is to provide more detailed summary information on core inland monitoring program elements of the DEEP Water Monitoring and Assessment Program at a level not found in the IWQR. For interested parties, raw data summarized in this report is available by request from the WPLR Monitoring and Assessment Program (860-424-3735).

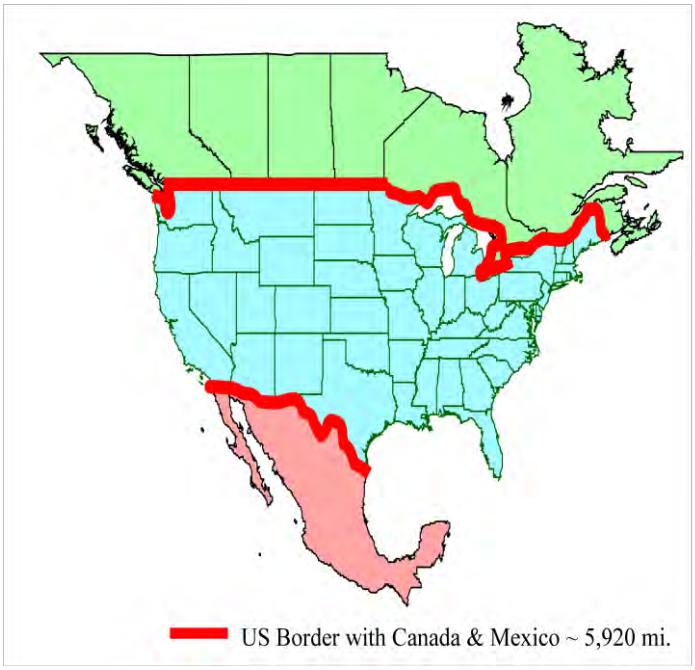


Introduction

The Monitoring and Assessment Program http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325616&depNav_GID=1654 is an important component of DEEP's mission to document the condition of the aquatic resources of the state. This report provides a review of the WPLR core inland program elements mixing some scientific explanation coupled with summaries to provide information on the water resources in Connecticut. This report supplements our more traditional reporting under the CWA, and our hope is that this format will reach broader audiences than our more formal approaches as required by Federal Law. Federal CWA requirements are more thoroughly explained in Connecticut's Water Quality Standards (WQS) http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325620 and IWQR to Congress http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325610&depNav_GID=1654.

Connecticut has diverse water resources that include rivers, streams, wetlands, lakes, estuaries, and Long Island Sound (LIS). The focus of this report is on inland waters as information pertaining to LIS in summarized elsewhere on the DEEP website (http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325570&depNav_GID=1654) and the LIS Study website (http://longislandsoundstudy.net/).

WPLR strives to provide comprehensive coverage of our aquatic resources, however, this is a challenge as there are a total of approximately 5,830 miles of rivers and streams (USEPA 1993) within Connecticut. This is roughly equivalent to the linear miles of the border with the United States with Canada and Mexico combined.



Core Program Elements

Core inland ambient monitoring program elements covered in this summary report can be divided into:

- Wadeable streams
  - ✓ Biological
    - Macroinvertebrate community
    - Fish community
  - ✓ Water Column Chemistry
  - ✓ Water Temperature
  - ✓ Citizen-based water quality monitoring
  - ✓ Indicator Bacteria
- Tissue contaminants
- Non-wadeable rivers
- State-owned bathing beaches
- Lakes
- Special Projects

Each of the core inland program elements can evaluate one or more components or designated uses. For example, in wadeable streams, DEEP evaluates water chemistry, water temperature, macroinvertebrate community, fish community, periphyton community, and toxicity to assess the aquatic life designated use and also evaluates indicator bacteria to assess the recreational designated use. Simply stated, DEEP considers a variety of data to assess the health of waters in the state. More detail can be found in the Consolidated Assessment and Listing Methodology (CALM) section of the 2010 IWQR (CTDEEP, 2010b).

Ambient monitoring is the acquisition of data to characterize the physical, chemical or biological integrity of Connecticut's surface waters and was conducted to meet the following objectives:

- ✓ ***Evaluation of pollution control program effectiveness***
- ✓ ***Baseline characterization & identification of reference conditions of state's waters***
- ✓ ***Assessment of water quality trends***
- ✓ ***Evaluation of ecological damage due to episodic pollution events***
- ✓ ***Identification of existing and emerging pollution problems***
- ✓ ***Investigation of nuisance complaints***
- ✓ ***Meet reporting commitments required by State and Federal regulations.***

In order to achieve statewide coverage, as well as balance additional programmatic needs as mentioned above, WPLR has adopted two strategies; a rotating basin approach and probabilistic sampling.

The rotating basin approach uses the natural drainage basin boundaries to focus sampling priorities over a 1 year period. Over a 5 year period WPLR is able to sample approximately 350 sites statewide (CT-DEP, 1999). Major basins represent the largest geographic unit of natural drainage basins and are roughly equivalent to United States Geologic Survey (USGS) eight digit Hydrologic Unit Codes (HUCs). Major basins are used by WPLR as planning units for the rotating basin approach (Figure 1).

Major Basin Number	Major Basin Name	Year Sampled
1	Pawcatuck	2010
2	Southeast Coast	2010
3	Thames	2009
4	Connecticut	2008
5	South Central Coast	2007
6	Housatonic	2006
7	Southwest Coast	2007
8	Hudson	2006

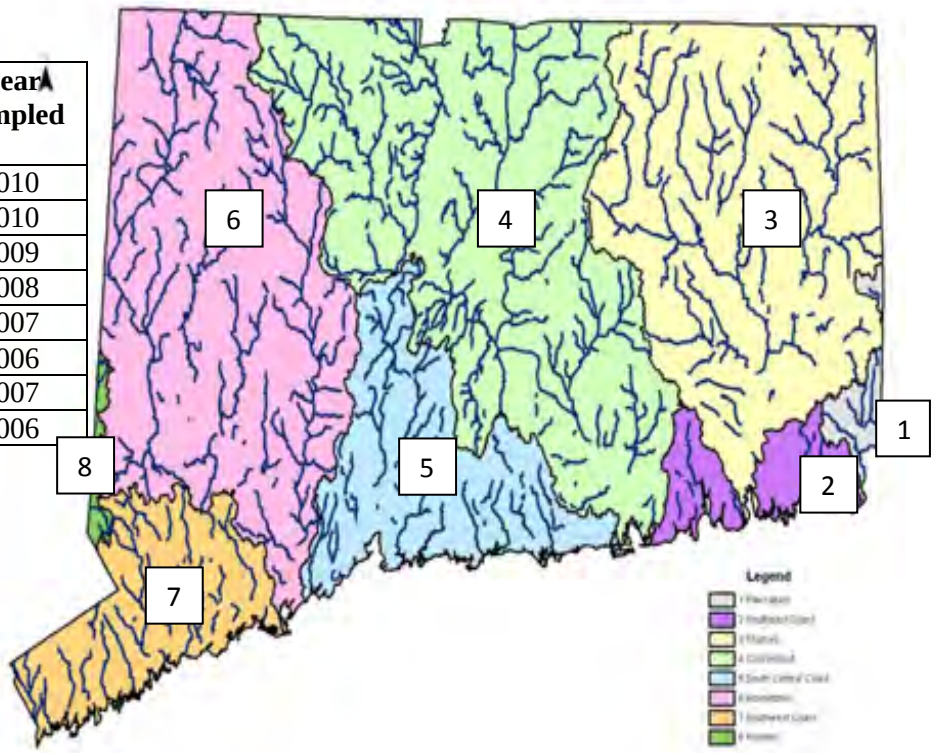


Figure 1 The eight major basins in Connecticut that are used for planning statewide rotating basin sampling.

The probabilistic approach uses a set of randomly selected point locations on streams and rivers across the state. A Generalized Random Tessellation Stratified (GRTS) survey design (Stevens and Olsen, 2004) was provided to DEEP from US EPA and implemented with a target population of streams based on the National Hydrography Dataset at the 1:24,000 scale.

Site Selection: Sampling stations were tentatively determined for the whole 5-year monitoring period, and then finalized each year prior to the beginning of any monitoring work. Types of sites sampled each year include several targeted categories: rotation, reference, index, and special project sites. Non-targeted, probabilistic sites were also sampled in each of the years. The rotation sites were chosen based on basin size, location of wastewater discharges, land use, and resource value.

Probabilistic sites were selected from a randomly generated list of sites from US EPA Corvallis and were used to make statewide Aquatic Life Use Support assessments (ALUS). In this case WPLR selected 100 points (large red dots) from the over 2,400 randomly provided by US EPA (small green dots)[Figure 2.] The major benefit of this approach is based in statistical theory that allows conclusions about an entire set of items (population) based on an adequate subset from that set of items (see "***The power of a probabilistic sampling design"*** below).

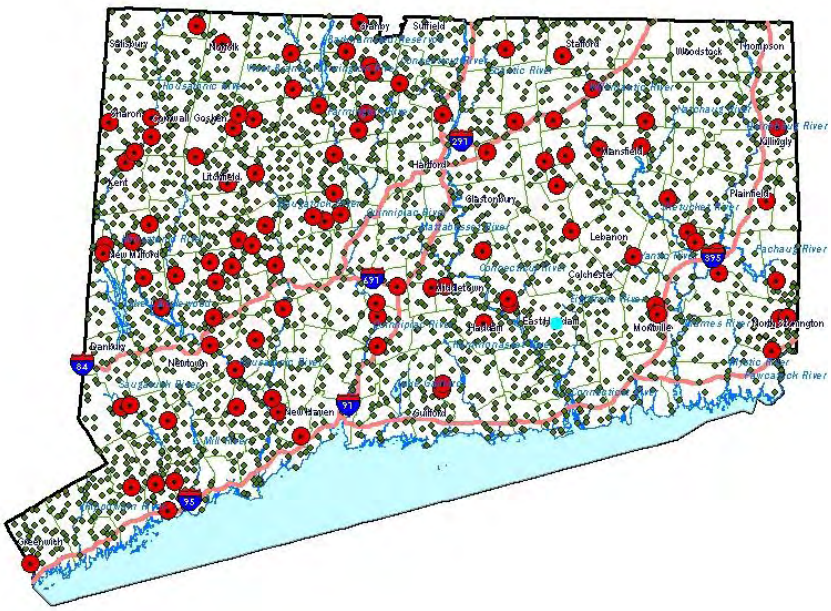


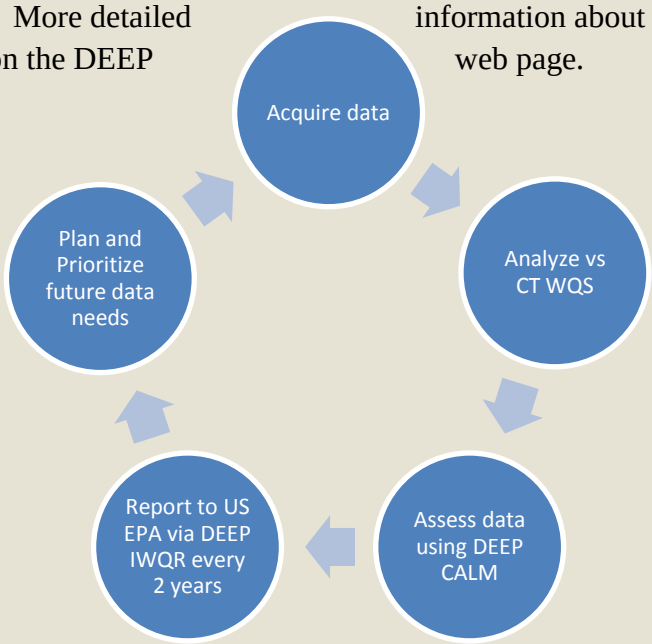
Figure 2. The approximately 2,400 points (small green dots) provided by US EPA to WPLR for probabilistic monitoring. Starting in sequence with site # 1, WPLR choose the first 100 sites (large red dots) appropriate for WPLR sampling methodology.

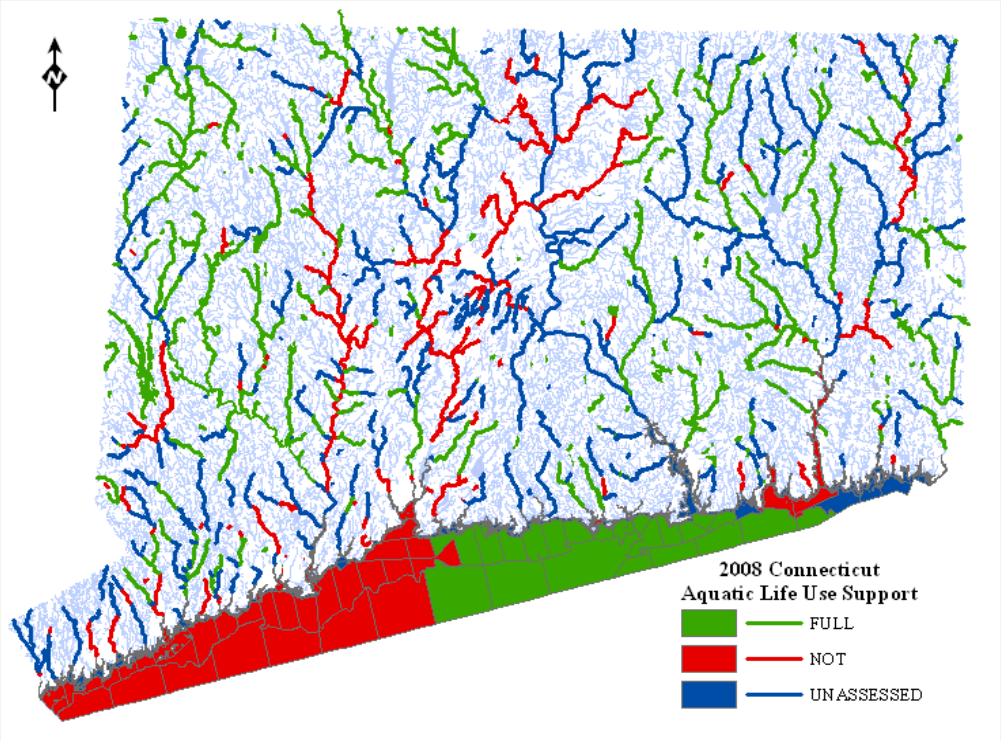
The power of a probabilistic sampling design:

As an example let's assume we would like to know something about a "population", in this case streams that are between 2 and 8 meters wide and have at least 1 species of trout present. To answer the question we would choose 100 randomly selected points, evaluate each to see if it is actually between 2 and 8 meters wide, and has appropriate habitat for trout. If the criteria are not met, a new site would be randomly selected until we have 100 sites meeting our "population". Next we would sample each site and observe if trout are present. If at the end of our survey 80 of the 100 stream sites had at least one species of trout present, we could predict on a statewide basis that trout will be absent from 20% of all streams between 2-8 meters wide and trout are present at 80% of streams between 2 and 8 meters wide.

Federal Clean Water Act Assessments

Under the CWA, every two years states are required to assess their aquatic resources and report on their status to US EPA. This is accomplished by having a series of designated uses including aquatic life, recreation, fish consumption, and others. This requirement sets in motion a continuous cycle where DEEP must acquire data, review data, and provide an assessment of these data. The map below shows an example of how the assessment of data used for aquatic life is reported in the IWQR. More detailed information about the IWQR, CALM, and WQS can be found on the DEEP web page.





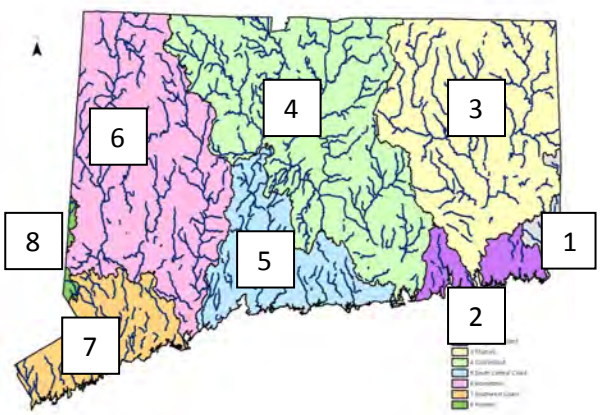
Presentation of Information

Between 2006 and 2010 greater than 25,000 thousand samples were collected generating over 1.2 million data points (Table 1). To manage this enormous quantity of raw data points, WPLR uses a relational database called the ambient water quality (AWQ) database. It is the goal of WPLR to migrate these data to the US EPA national water quality exchange, (WQX) database. For this report the raw values have been summarized and are presented in maps, tables, and summary graphs such as bar charts, line charts, pie charts and box plots (*aka* box and whisker plots). In addition, for some categories of data, general information is provided and may include a brief description of each parameter, the water quality criterion (if applicable), and implications to water quality. This summary is not meant to be an exhaustive report of programmatic elements, but rather highlights of the work WPLR conducts to monitor the State's aquatic resources. Macroinvertebrate, fish community, and water column chemistry data were filtered using the rotating basin strategy as the primary rationale for sample collection.

*Table 1. Totals for number of stations sampled, samples collected, and the number of records generated from work completed between 2006 and 2010. * indicates the data were collected by others than WPLR and are not currently in the AWQ.*

Data Category	Stations	Samples	Data Points
Biological-Macroinvertebrate community	309	309	101,141
Biological-Fish community	391	391	74,025
Water column chemistry	463	963	14,445
Water temperature	333	362	781,920
Citizen-based RBV	267	295	2,360
Citizen-based Water temperature	28	84	181,440
Citizen-based Water column parameters	47	11,190	67,140
Indicator Bacteria	122	4,235	4,235
Tissue Contaminants	148	453	916
Non-Wadeable Rivers	41	*	*
State Bathing Beaches	81	6,402	6,402
Lakes	76	*	*
Special Projects	70	450	10,524
Totals	**726**	**25,134**	**1,244,548**

In order to facilitate comparison and identification of the major basins for macroinvertebrate, fish community, and water column chemistry data, the box plots, data tables, and statewide maps have been color coded and numerically coded using a consistent legend by major basin throughout this report (Figure 3).

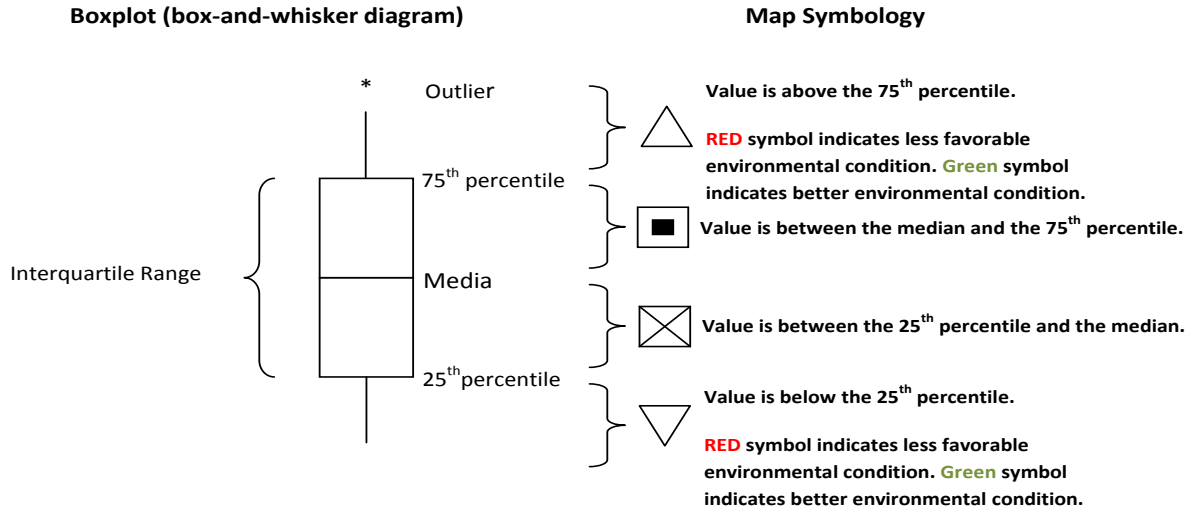


Major Basin	Legend Color
Statewide (all data 2006-2010)	No color
1 = Pawcatuck Major Basin (2010)	Grey
2 = Southeast Coast Major Basin (2010)	Purple
3 = Thames Major Basin (2009)	Yellow
4 = Connecticut Major Basin (2008)	Light Green
5 = South Central Major Basin (2007)	Light Blue
6 = Housatonic Major Basin (2006)	Pink
7 = Southwest Coastal Major Basin (2007)	Orange
8= Hudson Major Basin (2006)	Dark Green

Figure 3. The major basins and the colors used in data summaries found later in this report for macroinvertebrate, fish, and water column chemistry.

BOXPLOTS: A box plot (box-and-whisker diagram) is a graphical representation of the distribution of the data. It provides a quick format to view the spread and symmetry of a particular data set. A box plot consists of a box, whiskers, and outliers. The upper extent of the box is the 75th percentile, the lower extent is the 25th percentile, and the line dividing the box is the median value (50th percentile). The entire area bounded by the box is the inter-quartile range (plus or minus 25% of the median). The vertical lines above and below the box are called whiskers and represent data up to 1.5 times the inter-quartile range. Any data greater than 3 times the inter-quartile range is called an "outlier" and is displayed as an *.

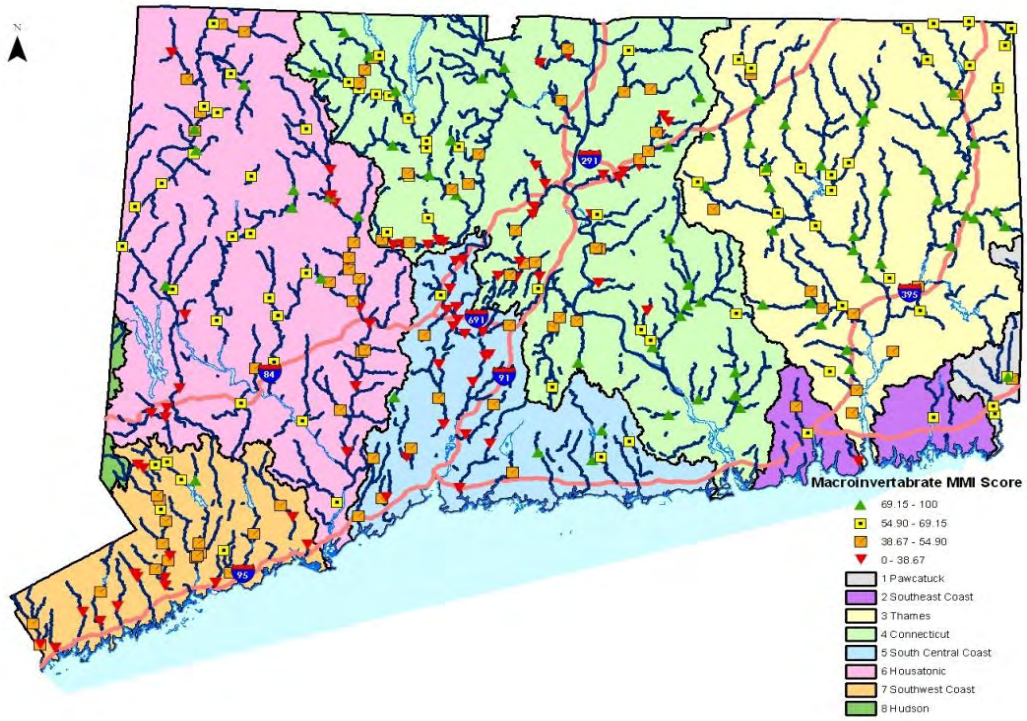
Legend for box plots and symbology found on the quartile maps presented within this report.



TABLES: Select summary statistics, some of which make up the box plot, are provided in a table and are broken out by major basin and include all raw data statewide. In these tables the major basin is the column heading and the statistic the row heading.

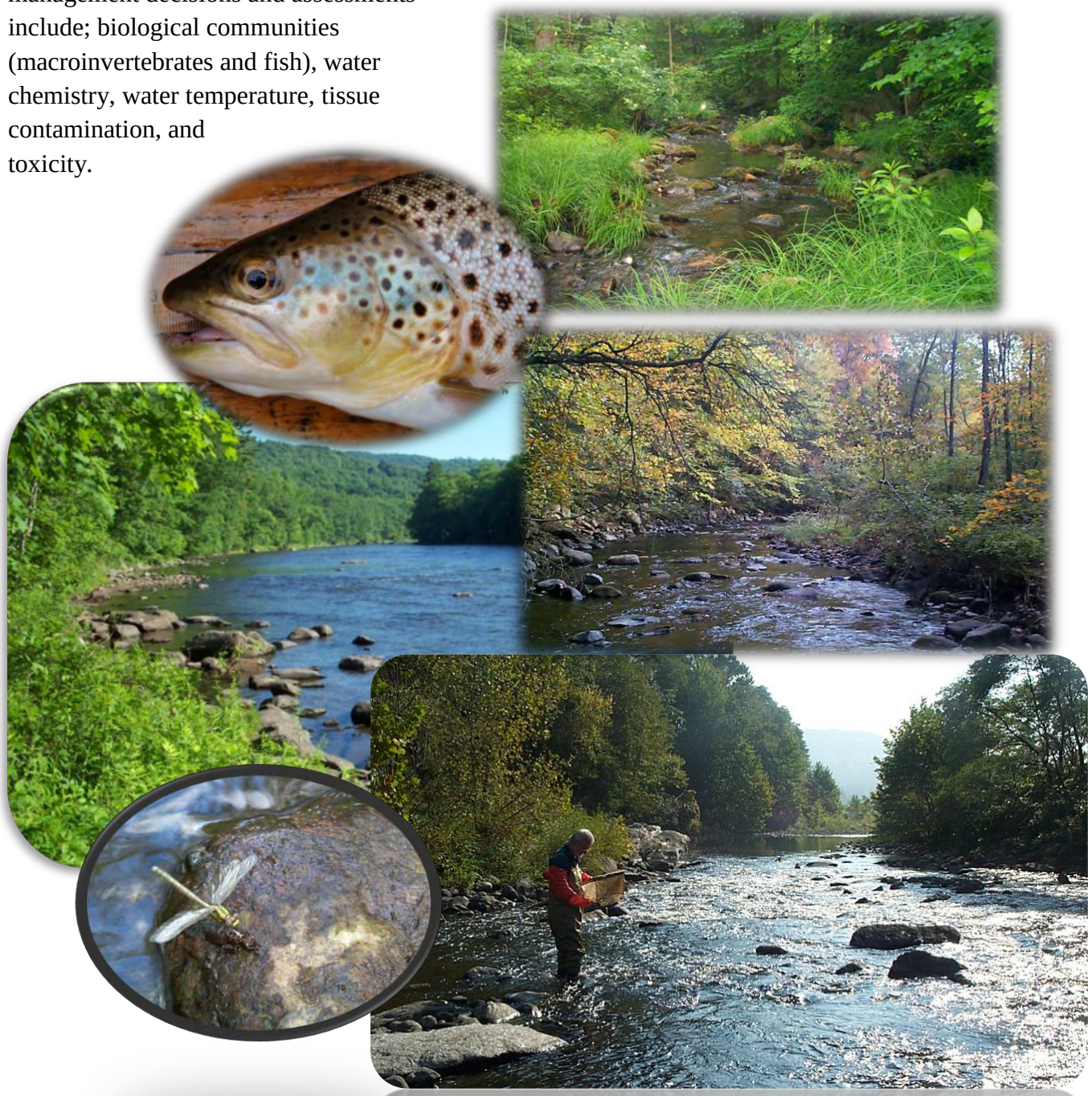
		Major Basin Number						
Statistics	**Statewide**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Count	**Value**							
Minimum								
Q1 (25th percentile)								
Mean								
Median								
SE Mean								
StDev								
Q3 (75th percentile)								
Maximum								

MAPS: The map legend indicates the distribution of the data for each parameter or measure of interest. Map symbology represents the quartiles of the data collected at that station location during the rotating basin strategy 2006-2010. <u>The map graphic represents the statistical distribution of the data and is not intended to imply water quality.</u> In general a green triangle indicates a favorable environmental condition and red triangle a less favorable condition.



Wadeable Streams

Of all of the core inland program elements, wadeable streams receive the greatest focus. In order to make accurate management decisions and water quality assessments, a considerable amount of information is required. Types of data utilized to make the management decisions and assessments include; biological communities (macroinvertebrates and fish), water chemistry, water temperature, tissue contamination, and toxicity.



Biological

Macroinvertebrate Community

Overview: WPLR utilizes the riffle-dwelling macroinvertebrates community to help characterize stream water quality. This is a community of animals without backbones, who inhabit fast-flowing shallow sections of rivers and streams. They come in all shapes and sizes, most are easily seen with the unaided eye. More information about this community can be found on the US EPA webpage at http://www.epa.gov/bioiweb1/html/invertebrate.html

WPLR has two index periods, September 15th - November 30th and April 1st - May 31st. WPLR considers the fall index period to better represent worst-case conditions than the spring index period ,as the fall macroinvertebrate community is exposed to the greatest level of stress from any potential water quality issue through the low-flow summer months. A complete description of sampling protocol is available in the Ambient Biological Monitoring-Benthic Macroinvertebrates Quality Assurance Project Plan (CT-DEP, 2003).

Macroinvertebrate Profiles

Most of the members within each of the 3 major orders below are very sensitive to water quality pollution. A very rich and diverse community made up primarily of members from these groups means a river/stream has minimal effects from pollution. Other major groups of macroinvertebrates are true flies, beetles, worms, crustaceans, and dragonflies.

Mayfly (Ephemeroptera): Species primarily live for only 1 year or less. Major "hatches" bring avid fly fishers to rivers and streams each spring to try and fool a large trout with a feathery mimic.

Stonefly (Plecoptera): More robust than the mayfly, stoneflies nymphs are usually very active. The fly fisher knows many of these as "wet flies".

Caddisfly (Trichoptera): A very diverse group of insects. The most common spin a net to capture fine particles for food. The most obvious build intricate shelters from either bits of sand and pebbles, sticks and leaves, or a mixture of both.

mayfly

stonefly

net-spinning caddisfly

case-building caddisfly

Macroinvertebrate images provide courtesy of Brian Duffy, New York Department of Conservation

How it was done: The following is a brief description of the macroinvertebrate collection and data assessment process. Sampling consists of 12 kick samples (stops) in the stream riffle using a rectangular net (18"x18"x10") with 500-micron mesh. All macroinvertebrates dislodged from the stream bottom are pushed into the net by the stream current and captured. A total of approximately two square meters are disturbed. This field sample is brought back to the WPLR laboratory where 200 organisms are removed using a random grid based system (Plafkin and others, 1989). A multi-metric index (MMI) score from 0-100 as well as a Biological Condition Gradient (BCG) score from 1 to 6 for the community is determined by based upon the list of species and their abundances in each sample (Gerritsen and Jessup, 2007). Monitoring of the benthic invertebrate community of wadeable stream segments has been conducted by WPLR since the mid 1970's. To date WPLR has collected macroinvertebrates from approximately 800 sites on just over 350 rivers.

Top 10 Macroinvertebrate Genera Found

1. *Cheumatopsyche sp., a caddisfly, (95.7%)*
2. *Hydropsyche sp., a caddisfly, (91.2%)*
3. *Maccaffertium sp., a mayfly, (85.1%)*
4. *Ceratopsyche sp., a caddisfly, (82.2%)*
5. *Chimarra sp., a caddisfly, (81.2%)*
6. *Optioservus sp., a beetle, (73.4%)*
7. *Oulimnius sp., a beetle, (71.2%)*
8. *Stenelmis sp., a beetle, (70.5%)*
9. *Tvetenia sp., a true fly, (66.9%)*
10. *Psephenus sp., a beetle (66.7%)*

A primary use of macroinvertebrate community structure assessments is to determine whether a section of stream supports or does not support the designated use goal for aquatic life as established by the State's Water Quality Standards (CTDEEP, 2011). The 2010 report and the assessment methodology used to generate the report (CALM) are available on the DEP web page (http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325610&depNav_GID=1654). Macroinvertebrate MMI scores are just one of several types of data that are used to generate the "final assessment" for aquatic life use as reported in the IWQR.

Narrative Criterion: *"Sustainable, diverse biological communities of indigenous taxa shall be present. Moderate changes, from natural conditions, in the structure of the biological communities, and minimal changes in ecosystem function may be evident; however, water quality shall be sufficient to sustain a biological condition within the range of Connecticut Biological Condition Gradient Tiers 1-4 as assessed along a 6 tier stressor gradient of Biological Condition Gradient." (CTDEEP, 2011b)*

Implications: Natural macroinvertebrate communities are typically comprised of a balance of many species from the major orders of aquatic insects (mayflies, stoneflies, caddisflies, true flies, dragonflies, and beetles). In addition there is a balance of different feeding strategies including shredders, filterers, and predators. When a diverse and robust community is present in a particular section of stream or river, WPLR interprets that to mean the narrative criterion above is met. Complete detail about the assessment methodology is available in the CALM. In general MMI values greater than 48 points and a BCG of two, three, or four may indicate support of the criterion.

Communities that are dominated by a few species and do not have a balance of feeding strategies are often indicative of some sort of water quality issue or disruption to the ecosystem. In these situations MMI scores tend to be less than 43 and have a BCG score of 5 or 6. These types of communities tend not to meet the water quality standard.

Macroinvertebrate MMI Results: In support of the 2006-2010 rotating basin strategy macroinvertebrate community samples were collected from 367 sites across Connecticut. From these samples the Thames major basin (3), had the highest median score for the state at 69.12 while the south central major basin (5) the lowest at 37.12. A range of community scores exists in each of the major basins with some sites scoring very low and others very high (Figure 4 and Table 2). The lowest MMI score of 6.37 was in the Hockanum River, downstream of the upper most Route 74 crossing in Vernon. The highest MMI score was 90.23 in Brown Brook, at Route 63 in Canaan. Comparison of scores statewide indicates the lowest MMI scores tend to follow the relatively high percentage of impervious land cover along the I-91 and I-95 corridors (Figure 5.)

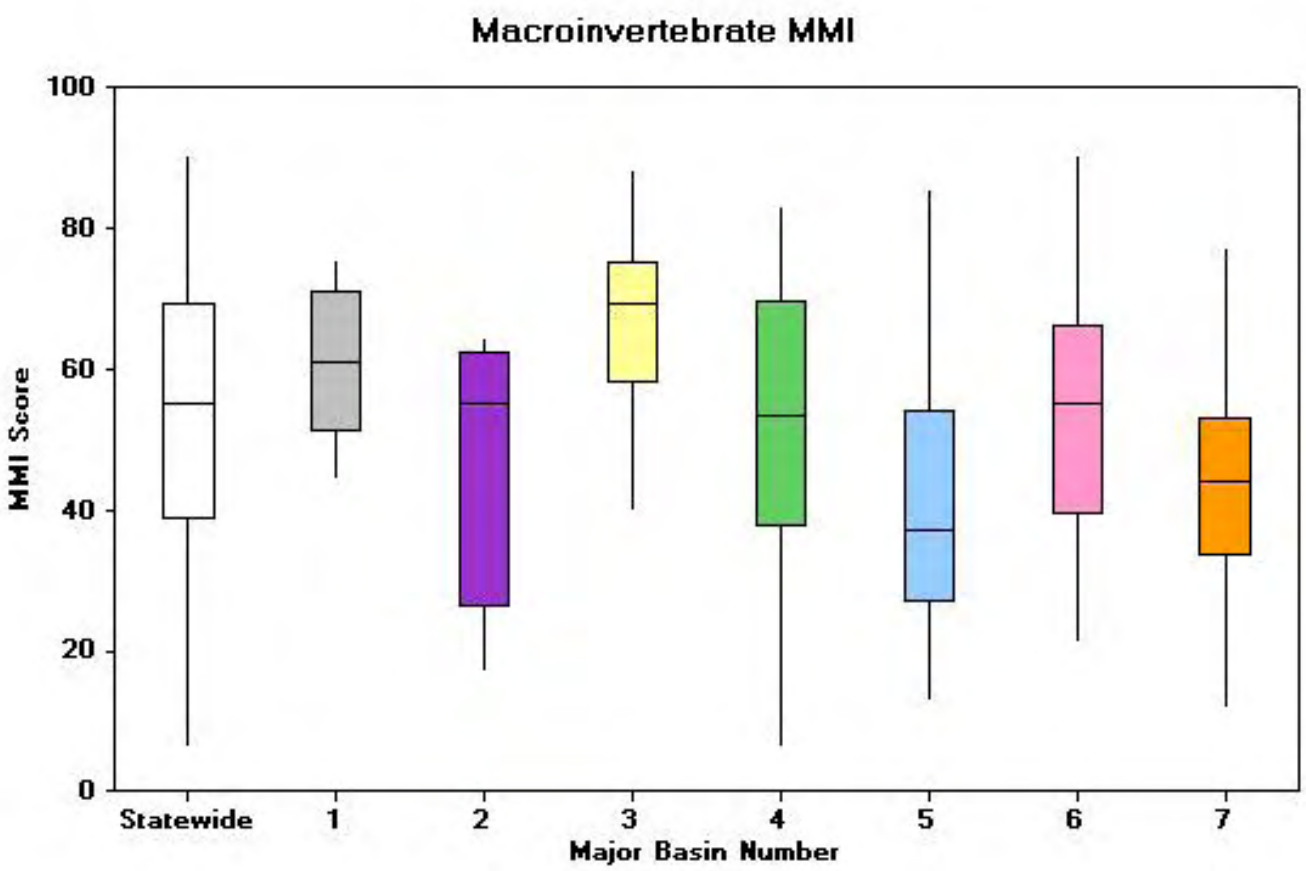


Figure 4. Box plots by major basin of macroinvertebrate MMI scores for fall samples collected in support of the 2006-2010 rotating basin strategy.

Table 2. Selected summary statistics for macroinvertebrate MMI scores for fall samples collected in support of the 2006-2010 rotating basin strategy.

Macroinvertebrate MMI Statistics	Major Basin Number							
	statewide	1	2	3	4	5	6	7
Count	309	5	4	66	101	35	61	37
Minimum	6.37	44.42	17.1	39.63	6.37	12.7	21.13	11.81
Q1 (25th percentile)	38.67	51.32	26.1	58.24	37.59	27.02	39.42	33.57
Mean	53.61	61.05	47.8	67.32	52.95	42.01	52.89	42.77
Median	54.9	60.81	54.9	69.12	53.45	37.12	55	44.09
Std Deviation	18.34	11.39	21	12.07	18.98	17.81	16.33	14.52
Q3 (75th percentile)	69.15	70.91	62.3	75.04	69.54	53.91	65.99	53.11
Maximum	90.23	75.39	64.2	88.11	83.04	85.35	90.23	77.19

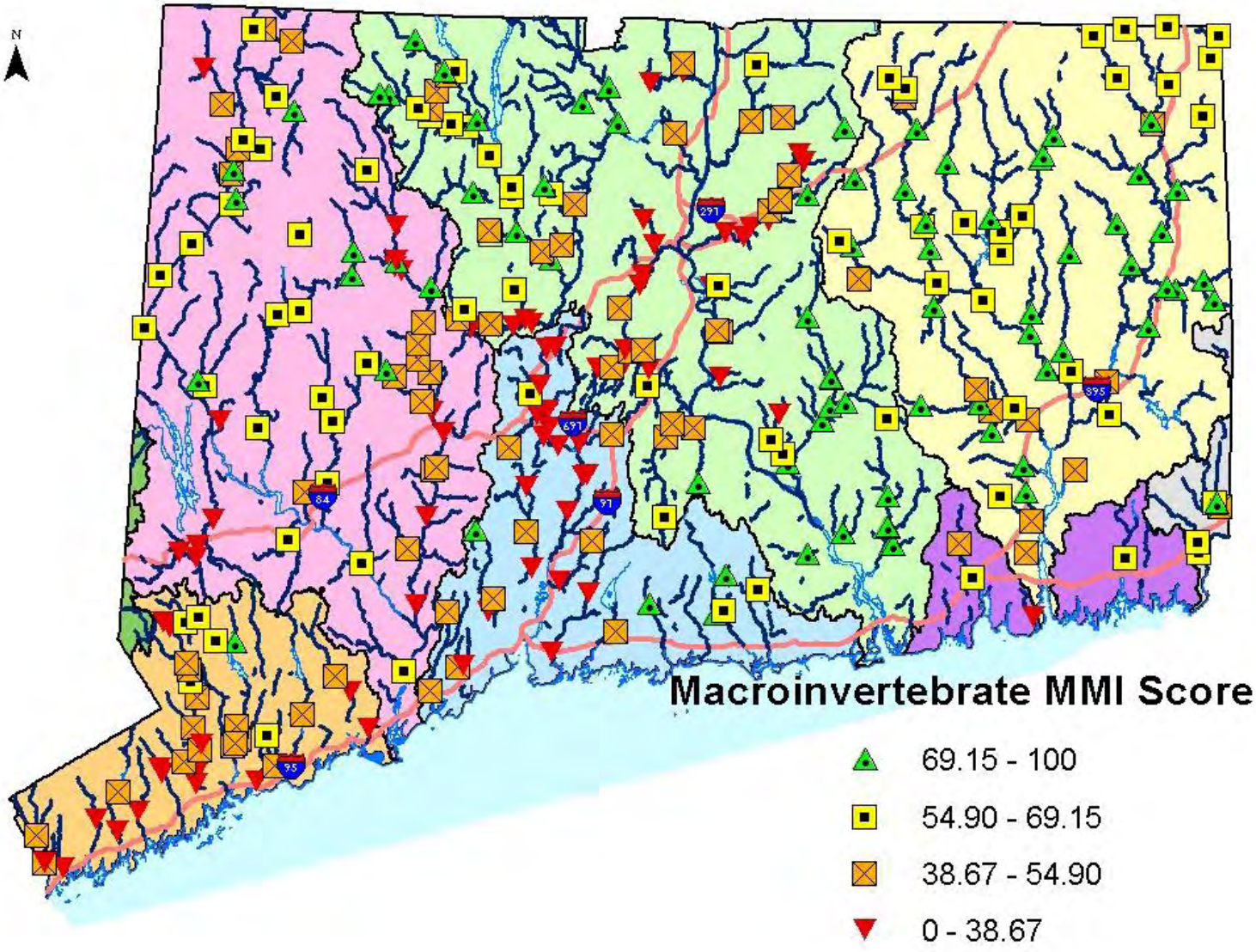
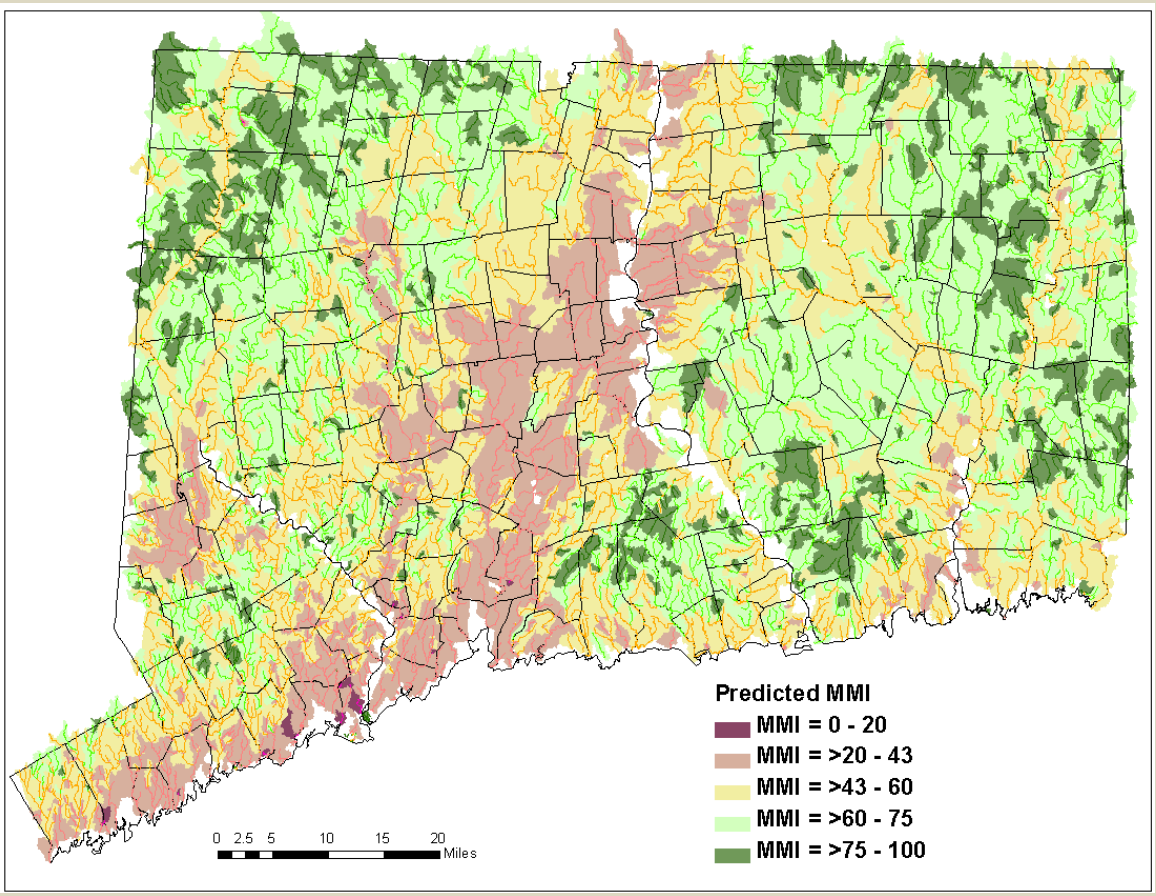


Figure 5. Distribution of macroinvertebrate MMI scores for fall samples collected in support of the 2006-2010 rotating basin strategy.

DEEP Project Highlight:

Macroinvertebrate MMI Predictive Model

Achieving state-wide coverage of the rivers and streams is a daunting task. Probability based sampling designs are an attempt to draw conclusions about the state's streams as a whole. However, these conclusions are general and do not help to provide insight to specific streams and rivers. In an attempt to have the best of both worlds, meaning to be able to know something about every stream and river, WPLR staff have developed a model by combining watershed attribute data, and macroinvertebrate data. The result was a predicative equation for macroinvertebrate MMI scores. With this tool, anyone with a question about a particular reach of stream or river can get a predicted or expected MMI score, even without macroinvertebrate data. The applications are extremely numerous but are particularly helpful for land use planning, water quality management, and identification of remaining high quality resources. A paper describing the model in detail is currently in press and should be available soon.



Macroinvertebrate Biological Condition Gradient

Overview: Complementary to the MMI is the macroinvertebrate Biological Condition Gradient (BCG). This is a model based upon "fuzzy" logic that attempts to mimic how trained environmental professionals would rank macroinvertebrate community data on a scale from 1 = completely natural to 6 = completely dysfunctional due to human disturbance (Gerritsen and Jessup, 2007).

The Connecticut Biological Condition Gradient Model (Figure 6) as incorporated into the State's WQS (http://www.ct.gov/dep/lib/dep/water/water_quality_standards/wqs_final_adopted_2_25_11.pdf) is based on published scientific literature (Davies and Jackson, 2006) and provides a model to illustrate the relationship between the amount of stress on the environment and its effect on biological communities. Stressors are diverse and may be biological, chemical or physical in nature. In accordance with the Biological Condition Gradient Model, as the level of stress gets progressively greater, the biological communities, which start out in a natural condition, begin to change as they respond to the stress. In general, this model is applicable to many different types of biological communities. Within the aquatic communities, it could be applied to fish, benthic invertebrates or periphyton communities, among others. In all cases, it provides a more refined scale by which the health of biological communities in Connecticut's ecosystems can be described relative to the conditions which affect them.

The BCG (biological condition gradient) is an ecological concept that states biological communities will respond to a stressor along a continuum. The gradient is anchored in the natural biological condition (Tier 1) and slides down to a severely dysfunctional condition (Tier 6). This gradient provides resource managers with a common language for comparison of different types of data, different methods of collection, and even different ecological systems. An attribute 2 is good no matter where, how, when or what is being evaluated. For more on the biological condition gradient visit the USEPA web page: http://www.epa. gov/bioiweb1/html/bcg.html

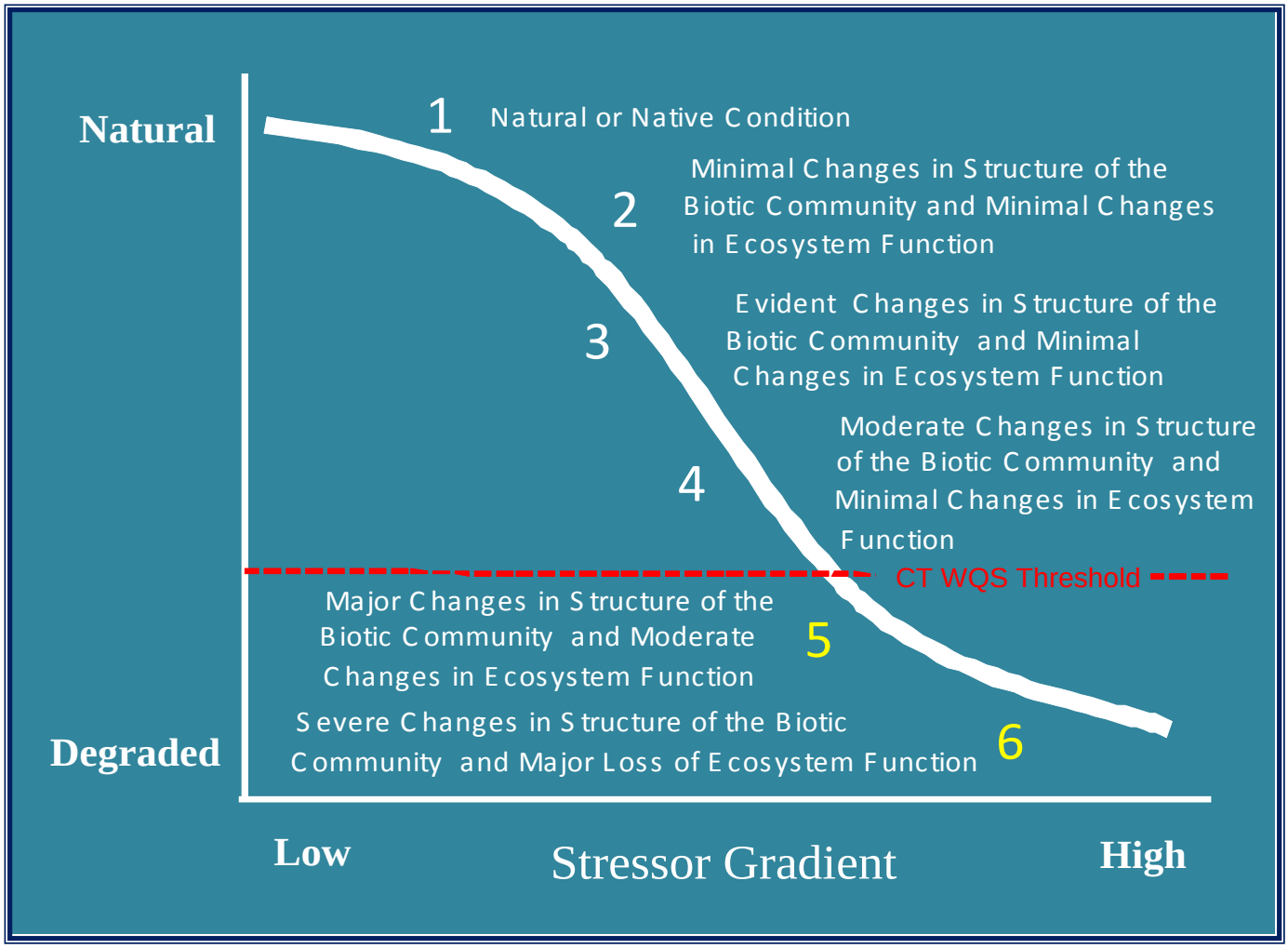


Figure 6. The Connecticut Biological Condition Gradient Model.

Macroinvertebrate BCG Results: BCG scores for each of the samples collected in support of the 2006-2010 rotating basin strategy ranged from 2-6. The statewide median value was "4" (Figure 7). The higher BCG scores indicative of less "natural" macroinvertebrate communities were typically found in the central valley and southwestern Connecticut (Figure 8). A BCG score of 1 is deemed not possible for Connecticut macroinvertebrate communities due to the extensive history of land use modification and deforestation since colonial settlement

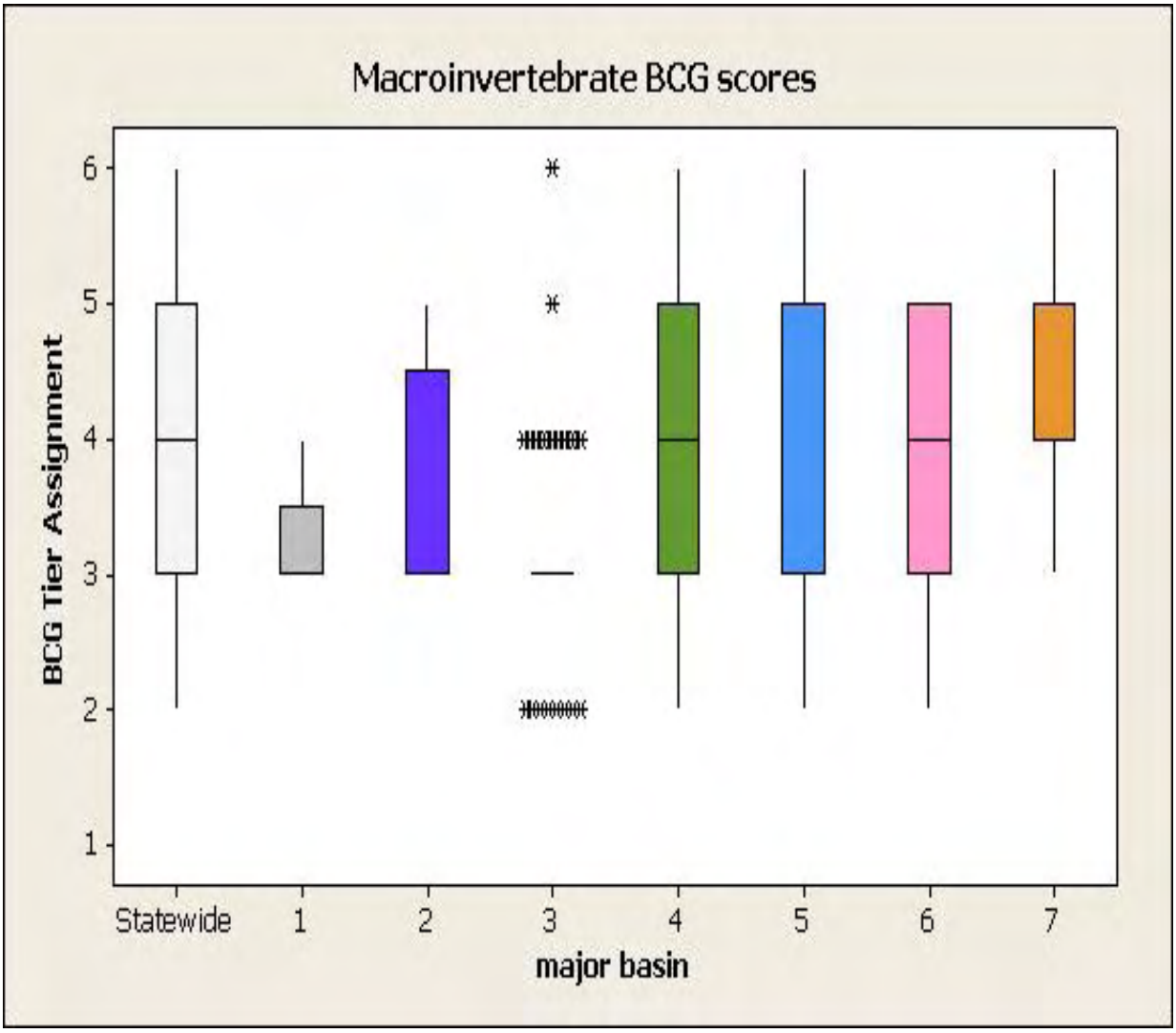


Figure 7. Box plot of macroinvertebrate BCG scores for macroinvertebrate MMI scores for fall samples collected in support of the 2006-2010 rotating basin strategy.

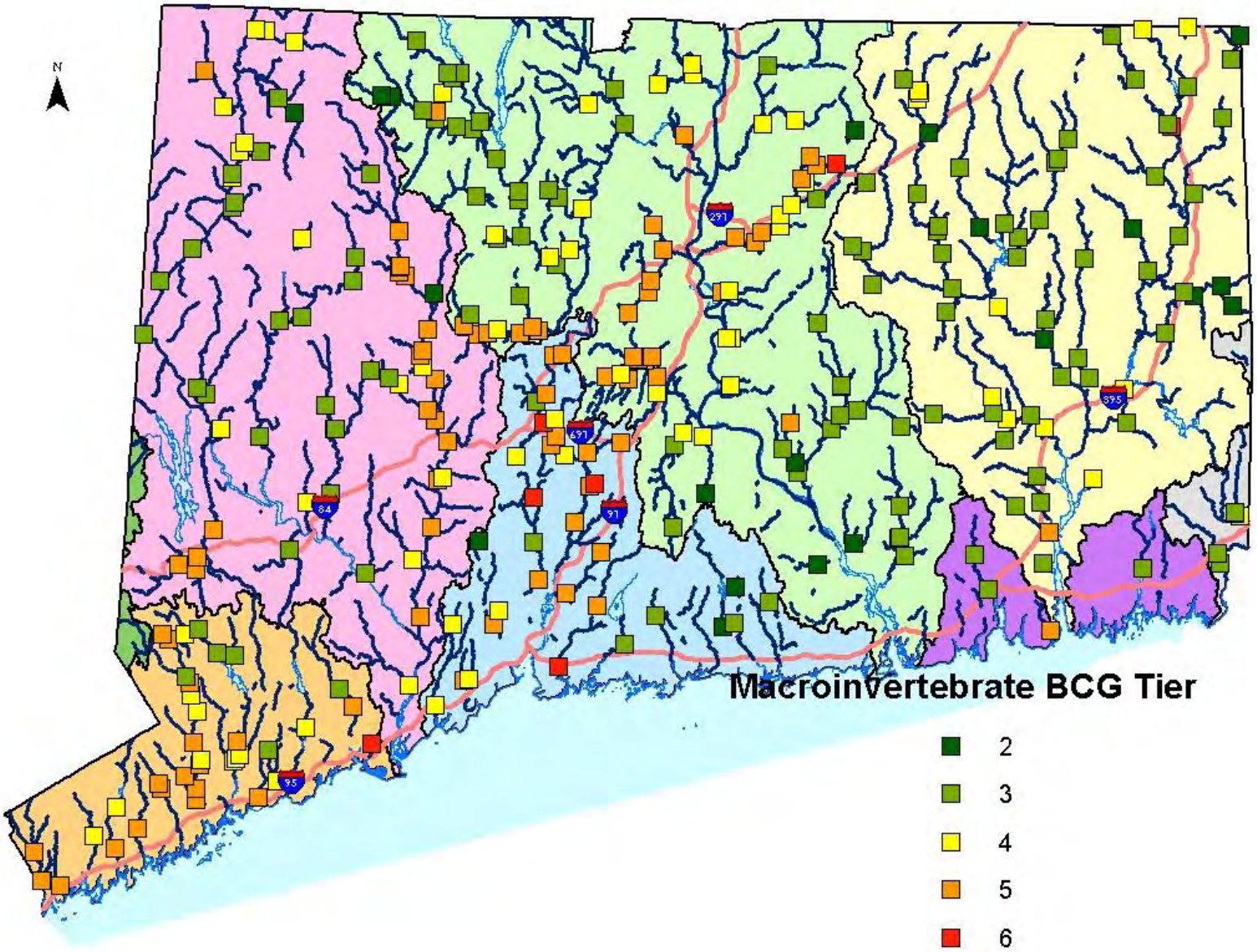
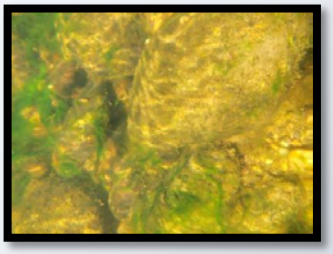


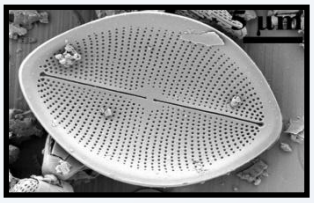
Figure 8. Distribution of macroinvertebrate BCG tier assignments for fall sample collected in support of the 2006-2010 rotating basin strategy.

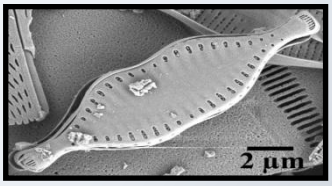
DEEP Project Highlight: Aquatic Life Response to Varying Enrichment Conditions in CT Freshwater Streams

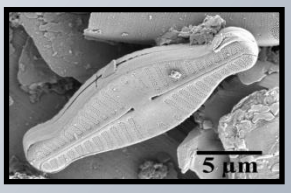
DEEP is conducting a study on aquatic life responses to varying enrichment conditions in Connecticut freshwater streams. This study is partially funded through an U.S. EPA 104(b)(3) and 604(b) grant. The focus of this project is to strengthen and refine DEEP's current efforts to develop effects based nutrient management goals through additional chemical and biological data collection and by expanding the current methodology to include non-waste receiving streams. Data collection of water chemistry, benthic algae and benthic macroinvertebrates across the range of enrichment conditions and varying nutrient loadings in Connecticut freshwater rivers and streams will help to establish differences in aquatic life response due to changes in enrichment conditions in Connecticut. It will also provide insight into the effects of excess nutrients through anthropogenic input on aquatic life communities. This understanding will help reinforce achievement of aquatic life use goals in all freshwater rivers and streams in Connecticut and will assist in guiding any necessary refinements to DEEP's current methodology to ensure that aquatic life uses are fully attained.



Benthic algae are the primary community of interest for this project because they are a biological community that responds directly to nutrients (Pan and Lowe, 1994; Pan and others., 1996). Benthic algae are micro- and macro algae that grow on the bottom substrate of a waterbody, such as rocks, logs and mud. This project concentrates on the collection of benthic microalgae in the Bacillariophyta group commonly referred to as diatoms. There are several types of microhabitats where diatoms are found. This project specifically focuses on epilithic diatoms. Epilithic diatoms grow on hard relatively inert substrata that are typically bigger than most algae, such as gravel, pebble, cobble and boulder (Stevenson and others, 1996). Diatoms are widely recognized and used as indicators of river and stream water quality including enrichment conditions (Stevenson and Pan, 1999). Several state agencies are using diatom trophic indices to aid in the development of nutrient criteria (Danielson, 2009; Ponader and others, 2007). For additional information regarding this project please contact Mary Becker, mary.becker@ct.gov







Diatom Images From Norwalk River At South Wilton CT: ANSP Algae Image Database from the Phycology Section, Patrick Center for Environmental Research, The Academy of Natural Sciences at http://diatom.acnatsci.org/AlgaeImage/

Didymosphenia geminata
A.K.A Didymo or Rock Snot

In late March 2011 the first occurrence in Connecticut of the invasive diatom, ***Didymosphenia geminata*** **(Didymo)** was documented in the West Branch Farmington River, Barkhamsted. Didymo is a single cell stalked diatom that prefers to live in cold-very low nutrient waters. This diatom produces a fiber-like stalk. When thousands of these stalks are combined a gooey, snot-like mass results, hence the name "Rock Snot". The texture of didymo is often described as feeling like wet wool. The strands will have some resistance when pulled apart and is not slippery. In other waterways worldwide where didymo has been introduced out of its native range it has caused nuisance blooms, blanketing the river bottom. Here in Connecticut, DEEP has not yet observed massive blooms but is monitoring the situation. Other states including New York and Vermont have confirmed didymo blooms and are also trying to educate the river-users on location of didymo and ways to prevent spread.

DEEP Inland Fisheries Division has posted informational signage, developed an informational brochure, and is working to educate the river-using public on the techniques to prevent the spread to other rivers and streams.

Humans are the primary vector responsible for the recent spread of didymo. Anglers, kayakers and canoeists, boaters and jet skiers can all unknowingly spread didymo. The microscopic cells can cling to fishing gear, waders (felt soles can be especially problematic), boots and boats, and remain viable for months under even slightly moist conditions. To prevent the spread of didymo to additional waters, DEP asks that anglers, especially those who also fish the Farmington River or streams outside Connecticut, and other users practice **CHECK, CLEAN, DRY** procedures.

- **CHECK:** Before leaving a river, stream or lake, remove all obvious clumps of algae and plant material from fishing gear, waders, clothing & footwear, canoes & kayaks, and anything else that has been in the water and look for hidden clumps. Leave them at the site. If you find any later, clean your gear and dispose of all material in the trash.
- **CLEAN:** Soak/spray & scrub boats and all other "hard" items for at least one minute in very hot (140°F) water, a 2% bleach solution, or a 5% dishwashing detergent solution. Absorbent materials such as clothes and felt soles on waders should be soaked for at least 40 minutes in very hot water (140°F), or 30 minutes in hot water (115°F) with 5% dishwashing detergent. Freezing thoroughly will also kill didymo.
- **DRY:** If cleaning is not practical, after the item is completely dry to touch, wait an additional 48 hours before contact or use in any other waterway.

More information about didymo can be found on the DEEP web page at:
http://www.ct.gov/dep/cwp/view.asp?A=4013&Q=476204

Biological Fish Community

Overview: Fish are an important component of aquatic life in wadeable rivers and streams in Connecticut and WPLR recently began to incorporate fish into stream ALUS assessments. This process started in 1999 with a cooperative project with DEEP Inland Fisheries Division and has continued over the last 11 years. This rich fish community database has formed the background necessary to develop a set of tools that has allowed WPLR to incorporate fish community data into the ALUS assessments. More information about using fish as indicators of water quality can be found on the USEPA webpage at http://www.epa.gov/bioiweb1/html/fish.html

Fish community work is challenging because Connecticut has a very limited pool of species and fish community structure at any given point in a stream or river is influenced by the upstream watershed area and water temperature regime, as well as any human influences like dams, water withdrawal, or water quality issues. After many years two (2) fish community multi metric indices were developed in cooperation with UConn's Department of Natural Resources and the Environment,-the cold water MMI (CWMMI) and the mixed water MMI (MWMMI). The CWMMI is generally used for fish community data from locations with an upstream watershed area of 20 km^2 or less and the MWMMI is generally used for sites with upstream watershed area greater than 20 km^2 (Kanno and others 2010). A second tool, a fuzzy set model that will place a fish community sample along the BCG, is in development and could be completed for the 2014 IWQR assessment cycle.

Top 10 Fish Species Found

1. Blacknose Dace (97.3%)

2. White Sucker (91.2%)

3. American Eel (67.5%)

4. Tessellated Darter (64.5%)

5. Longnose Dace (62.3%)

6. Brook Trout, Wild (46.2%)

7. Bluegill Sunfish (45.5%)

8. Fallfish (44.5%)

9. Common Shiner (38.1%)

10. Brown Trout, naturalized (36.1%)

Ambient fish community data are collected by electrofishing, a non-lethal capture method. Typically, as many fish as possible are netted, identified to species, and measured for total length to the nearest centimeter (CT-DEP, 2000). Annual summaries of fish community work are available on the DEEP web page at: http://www.ct.gov/dep/cwp/view.asp?a=2719&q=487892&depNav_GID=1654

Narrative criterion*:* *"Sustainable, diverse biological communities of indigenous taxa shall be present. Moderate changes, from natural conditions, in the structure of the biological communities, and minimal changes in ecosystem function may be evident; however, water quality shall be sufficient to sustain a biological condition within the range of Connecticut Biological Condition Gradient Tiers 1-4 as assessed along a 6 tier stressor gradient of Biological Condition Gradient."(CTDEEP 2011b).*

Implications*:* The structure of a fish community at any given point of a stream or river in Connecticut depends upon both natural and human influenced variables. Naturally, the size of the stream and the water temperature regime (cold, cool, warm) dictate which species could be present. In addition human influences include; damming of rivers, water withdrawal, water quality, and stocking fish for recreational purposes.

In general fish communities change from a trout dominated community in small cold water brooks and streams to a diverse community comprised of several minnow species, white sucker, darter, and eel in medium cool water streams, to finally sunfish and bass dominated systems in large warm rivers.

To evaluate the condition of small brooks and streams the CWMMI is used. In general values above 40-45 points indicate a community that would meet the water quality standard. For medium to large streams and rivers the MWMMI is used with scores above 40-45 again indicating support of the water quality standard. Values much less than 40 tend to indicate that a fish community has deviated substantially from the standard and may not be in support. Often with fish, that are more sensitive to the amount of water in a stream than invertebrates, failing scores may be due to only a few individuals being present in the stream reach. Complete details about the assessment methodology are available in the CALM.

Cold Water MMI Results In support of the 2006-2010 rotating basin strategy 189 fish community samples were collected in small streams (upstream watershed area of 15-20 km2 or less). When a CWMMI score was calculated, (sites with no fish cannot have an MMI score), values ranged from the low single digits to low seventies. Major basin 2 had the lowest median score statewide with basin 7 having the lowest scores of any major basin (Figure 9, 10 and Table 3). The CWMMI is heavily dependent upon the presence of obligate cold water species, those that require very cold water to complete their life cycle, such as the Eastern Brook Trout (*Salvelinus fontinalis*) and Slimy Sculpin (*Cottus cognatus*). When these species are present the scores tend to be high, when absent, low.

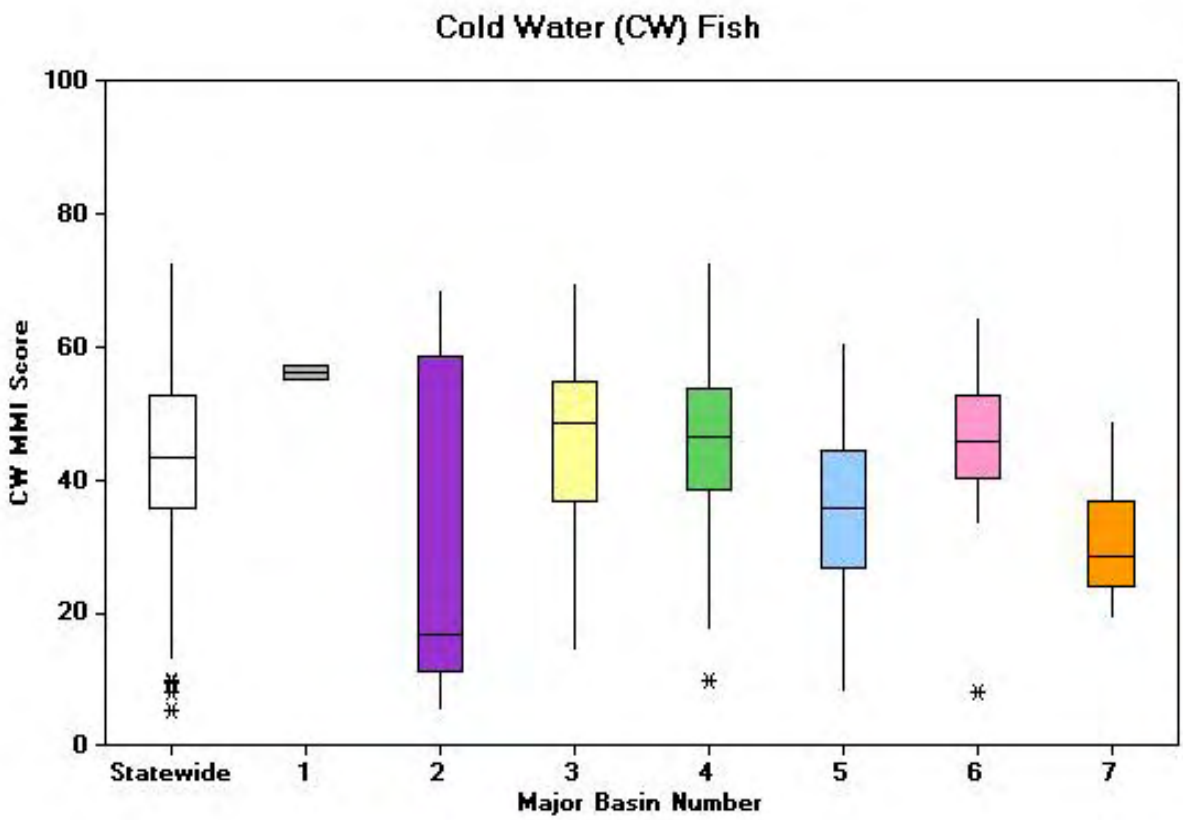


Figure 9. Box plot by major basin of fish CWMMI scores for fish community samples collected in support of the rotating basin strategy 2006-2010.

Table 3. Selected summary statistics for fish CWMMI scores for samples collected in support of the rotating basin strategy 2006-2010.

Cold Water MMI Statistics	Major Basin Number							
	statewide	1	2	3	4	5	6	7
Count	189	2	6	35	74	28	35	9
Minimum	5.27	55	5.3	14.24	9.52	8.08	7.84	19.17
Q1 (25th percentile)	35.69	NA	11	36.85	38.46	26.56	40.03	24.02
Mean	42.6	56.09	29.2	45.12	45.47	34.74	44.92	30.51
Median	43.25	56.09	16.7	48.58	46.21	35.55	45.61	28.54
StDev	13.59	1.54	26	12.59	12.44	13.6	10.1	9.32
Q3 (75th percentile)	52.74	NA	58.5	54.75	53.77	44.27	52.72	36.66
Maximum	72.61	57.18	68.6	69.44	72.61	60.54	64.38	48.84

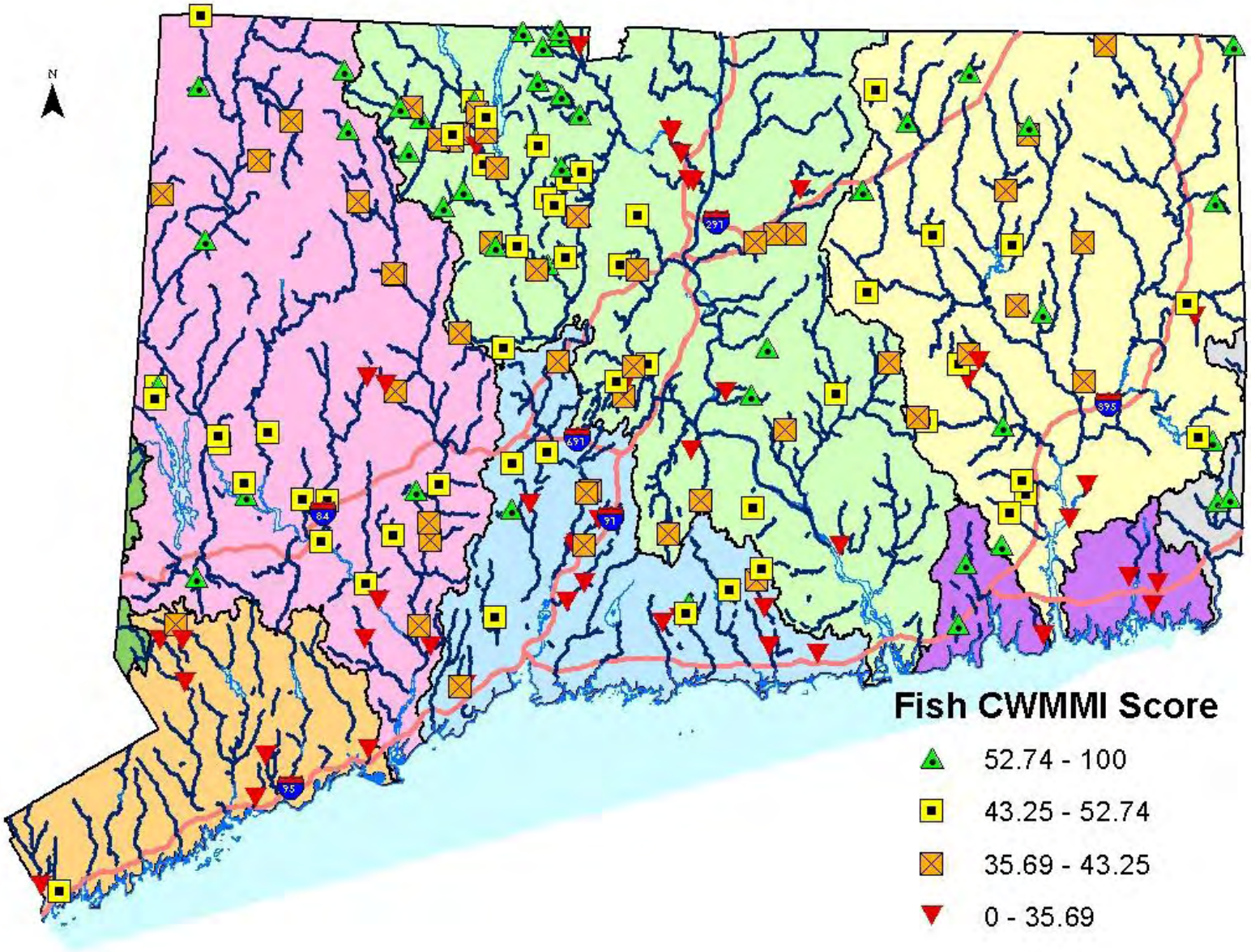


Figure 10. Distribution of fish CWMMI scores at sites sampled in support of the rotating basin strategy 2006-2010.

Mixed Water MMI Fish Results

In support of the 2006-2010 rotating basin strategy 202 fish community samples were collected in medium to large streams (upstream watershed area is greater than 15-20 km^2). When a score was calculated, (sites with no fish cannot have an MMI score), values ranged from the low single digits to high seventies. Major basin 5 had the lowest median score statewide and tended to have lowest scores overall (Figure 11, 12 and Table 4). The MWMMI is heavily dependent upon the presence of native fluvial specialist species, those that need to have rapidly flowing water to complete their life cycle, such as the fallfish, common shiner, tessellated darter, and white sucker. When these species are present and the community is in good balance the scores tend to be high, when key species are absent or the community is over dominated by one species, the scores tend to be lower.

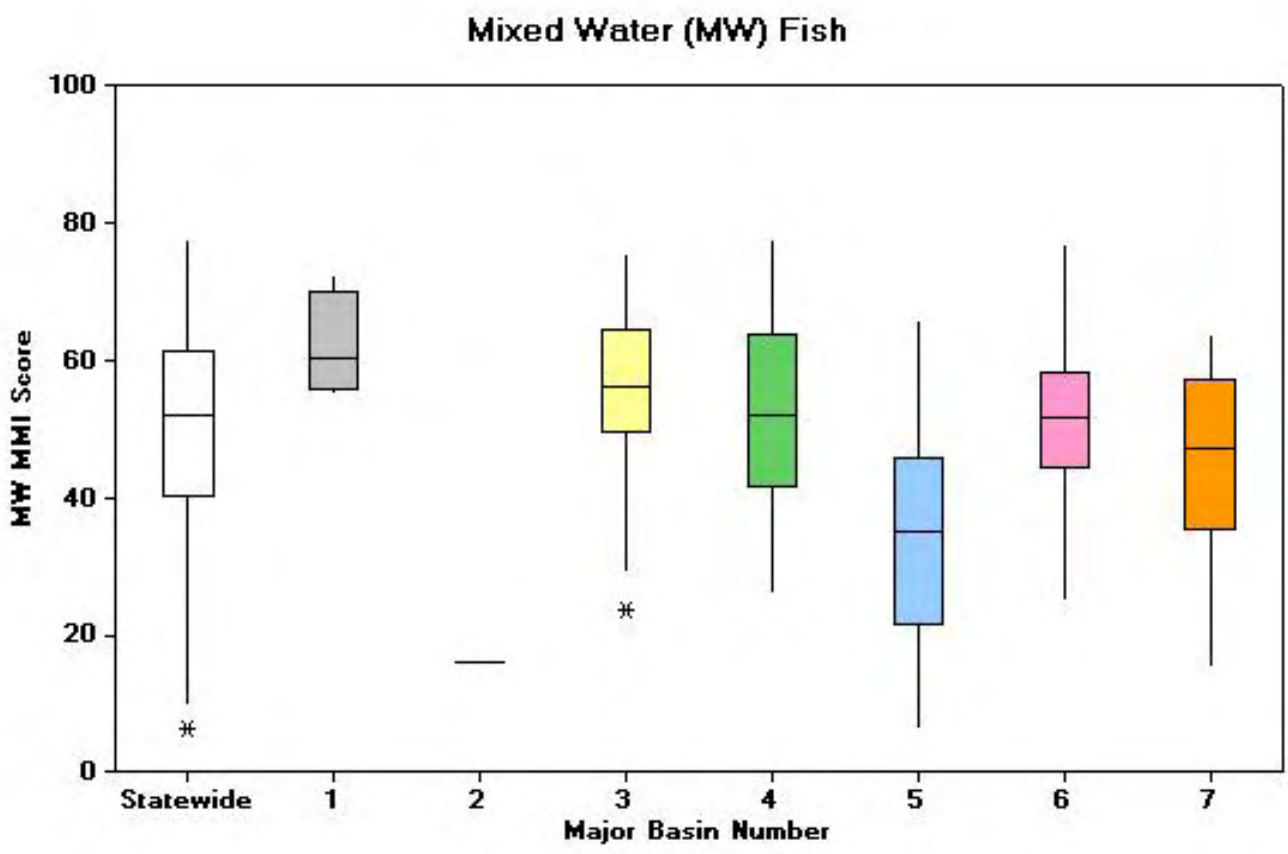


Figure 11. Box plot by major basin of fish MWMMI scores for fish community samples collected in support of the rotating basin strategy 2006-2010.

Table 4. Selected summary statistics for fish MWMMI scores for samples collected in support of the rotating basin strategy 2006-2010.

Mixed Water MMI Fish Statistics	Major Basin Number							
	statewide	1	2	3	4	5	6	7
Count	202	4	1	51	64	22	39	21
Minimum	6.35	54.85	16	23.41	26.1	6.35	24.87	15.22
Q1 (25th percentile)	40.29	55.76	NA	49.62	41.51	21.47	44.32	35.37
Mean	50.38	61.96	16	56.1	51.66	34.94	51.74	45.68
Median	51.89	60.28	16	55.89	51.78	35.03	51.65	46.99
StDev	14.47	7.58	NA	11.02	13.42	16.69	12.5	13.08
Q3 (75th percentile)	61.38	69.85	NA	64.2	63.63	45.77	58.28	56.92
Maximum	77.39	72.44	16	75.56	77.39	65.58	76.76	63.56

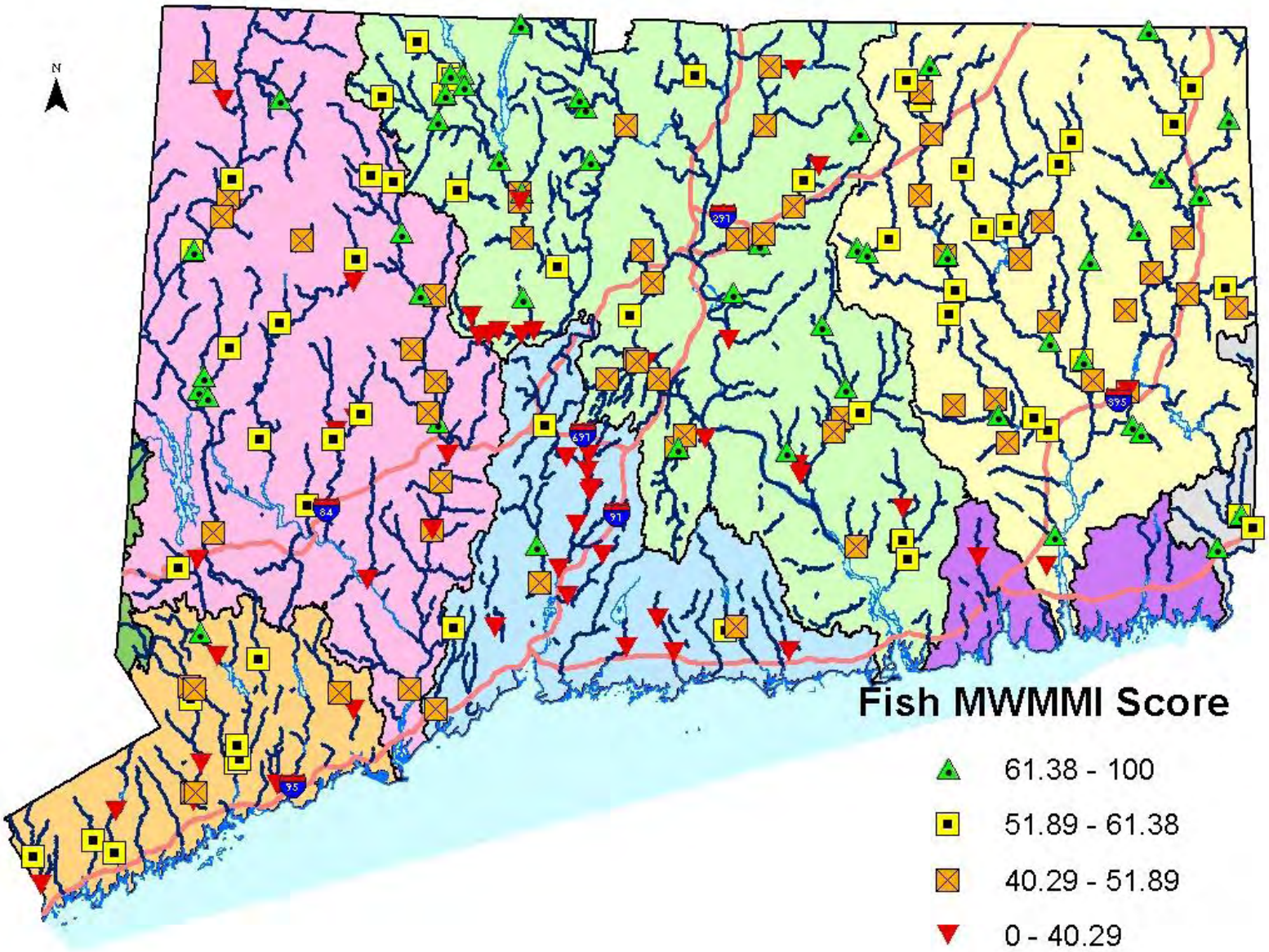
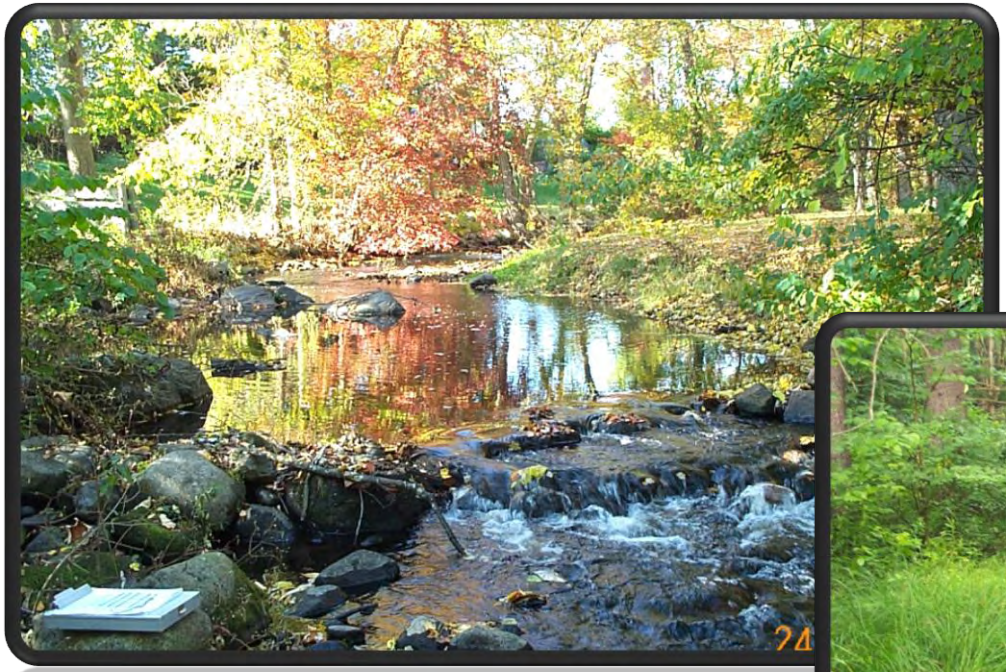


Figure 12. Distribution of fish MW MMI scores at sites sampled in support of the rotating basin strategy 2006-2010.

Fish habitat and water temperature: Water temperature is one of the primary factors that can affect the fish community at any given location. Current thought classifies streams into 1 of 3 temperature habitat types; cold, cool, and warm. DEEP is currently looking to update the water quality criterion for water temperature and is considering these temperature classes as a framework http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325618&depNav_GID=1654. Table 5 below provides some information on these three water temperature habitat types.



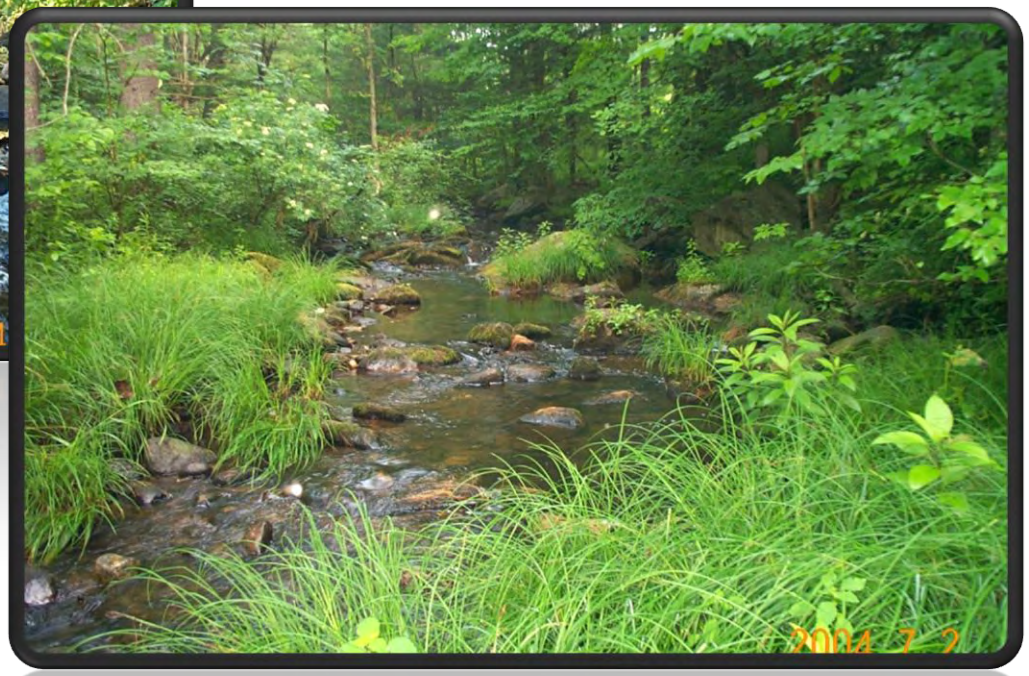


Table 5. Water temperature is an important variable for fish communities. Depending upon the summer values streams can be classified as cold, cool or warm.

Water Temperature	Range (Lyons and others 2009)	Water temperature habitat information	Fish species typically found in this habitat type
Cold	Daily maximum always below 20 ^{o}C (68 ^{o}F) especially in summer with daily mean below 18 ^{o}C (64.4 ^{o}F)	In general this habitat is found in Connecticut in areas with higher elevations, steep gradient, and substantial groundwater input. WPLR is currently collecting long-term water temperature data from selected cold water habitats throughout Connecticut (CTDEP 2010b).	slimy sculpin (*Cottus cognatus*) and eastern brook trout (*Salvelinus fontinalis*)
Cool	Maximum daily summer temperatures can be between 20 ^{o} C (68 ^{o}F) and 24 ^{o}C (75.2 ^{o}F) with mean summer temperatures between 18 (64.4 ^{o}F) and 21 ^{o}C (69.8^{o} F).	In general, this habitat is the primary type of fish habitat in Connecticut and can be found in a variety of stream sizes, elevations, and gradients. The highest quality mixed water fish habitat supports a diverse community consisting primarily of native minnow species.	fallfish (*Semotilus corporalis*), common shiner (*Luxilus cornutus*), blacknose dace (*Rhinichthys atratus*), longnose dace (*Rhinichthys cataractae*), cutlips (*Exoglossum maxillingua*), creekchub (*Semotilus atromaculatus*) as well as other native species such as white sucker (*Catostomus commersonii*), American eel (*Anguilla rostrata*) and tessellated darter (*Etheostoma olmstedi*). Fallfish Common shiner Blacknose dace Longnose dace Creek chub Tessellated darter
Warm	Can have daily mean temperatures that exceed 24 ^{o}C (75.2 ^{o}F) in summer.	In general, this habitat is primarily found in medium to large rivers with low gradient. However, due to the extensive historical damming of many small streams, small pockets of warm water habitat dot the landscape where it would otherwise be cool or cold water habitat. High quality natural warm water fish habitat can support a diverse community consisting of native sunfish and pickerel species.	pumpkinseed sunfish (*Lepomis gibbosus*), chain pickerel (*Esox niger*), red fin pickerel (*Esox americanus*) and brown bullhead (*Ameiurus nebulosus*). It is also home to several lesser known and rarely seen native fish species such as creek chubsucker (*Erimyzon oblongus*), swamp darter (*Etheostoma fusiforme*), banded sunfish (*Enneacanthus obesus*), and bridled shiner (*Notropis bifrenatus*). Pumpkinseed Redfin pickerel Brown bullhead

DEEP COOPERATIVE PROJECT HIGHLIGHT:

DISTRIBUTION OF CRAYFISH SPECIES WITHIN CONNECTICUT STREAMS

Electro fishing surveys can stun more than just fish. In addition to our intended targets crayfish are often netted as part of the catch. Until recently very little information was readily available about the distribution of crayfish species in Connecticut. Unlike their insect counterparts, it was always assumed that crayfish were ubiquitous and therefore were little help in assessing water quality. Together WPLR and Inland Fisheries have been documenting crayfish species while electro fishing and providing this information to DEEP Bureau of Natural Resources Wildlife Division, so as to have a better understanding of the species present in Connecticut rivers and streams as well as the distribution of each species across the state. Annual summary reports are available on the DEEP web site at http://www.ct.gov/dep/cwp/view.asp?a=2719&q=487892&depNav_GID=1654

Species	Distribution	Notes
Cambarus bartonii	limited	few streams in western CT
Cambarus robustus	statewide	very common especially in higher gradient streams
Orconectes immunis	unknown	not often collected in streams
Orconectes limosus	statewide	very common all streams
Orconectes neglectus	limited to Hudson Major Basin	only a few streams in CT that drain to the Hudson
Orconectes virilis	statewide	very common especially warmer lower gradient streams
Oronectes rusticus	primarily Housatonic Major Basin	very abundant when present especially larger rivers like the Housatonic
Procambarus acutus	primarily eastern CT	more widespread than initially thought
Procambarus clarkii	limited	only 2 stream occurances with 1 individual each

Crayfish pictures courtesy of Robert Jacobs, Supervising Fisheries Biologist, CT DEEP.

Aquatic Life Use Support- Statewide Estimate via Probabilistic Monitoring 2010

To obtain a statewide assessment of aquatic life use support in wadeable streams, 100 wadeable stream sites were sampled between 2006 and 2010. Data from these sites were extrapolated out to all wadeable streams within Connecticut. As such seventy-seven (77) percent of wadeable streams were fully supporting of aquatic life use, 22% were not supporting, and 1% had insufficient information to make a reliable assessment (Table 6).

Spatially, the 100 streams assessed for aquatic life use support follow patterns observed in past work in Connecticut. That is, land cover, specifically impervious land cover, is an important consideration when determining aquatic life use support in wadeable streams in Connecticut (Figure 13). For example, > 90% of the randomly selected stream sites that were not supporting aquatic life use were located in watershed that had >12% impervious cover in the watershed. For a more detailed discussion regarding aquatic life and the relationship with impervious cover see "impervious cover" in the special projects section near the end of this report.

Table 6. **Statewide assessment for aquatic life (based upon macroinvertebrate data) in wadeable streams in Connecticut. Samples (n=100) were collected from 2006-2010 using a Generalized Random-Tessellation Stratified Design.**

Use Support Category	Percent of Target	Standard Error	Upper and Lower 95% Confidence Intervals
Fully Supporting	**77**	**2.7**	**71.7-82.3**
Not Supporting	**22**	**2.6**	**16.9-27.2**
Insufficient Information	**1**	**0.8**	**0.0-2.7**

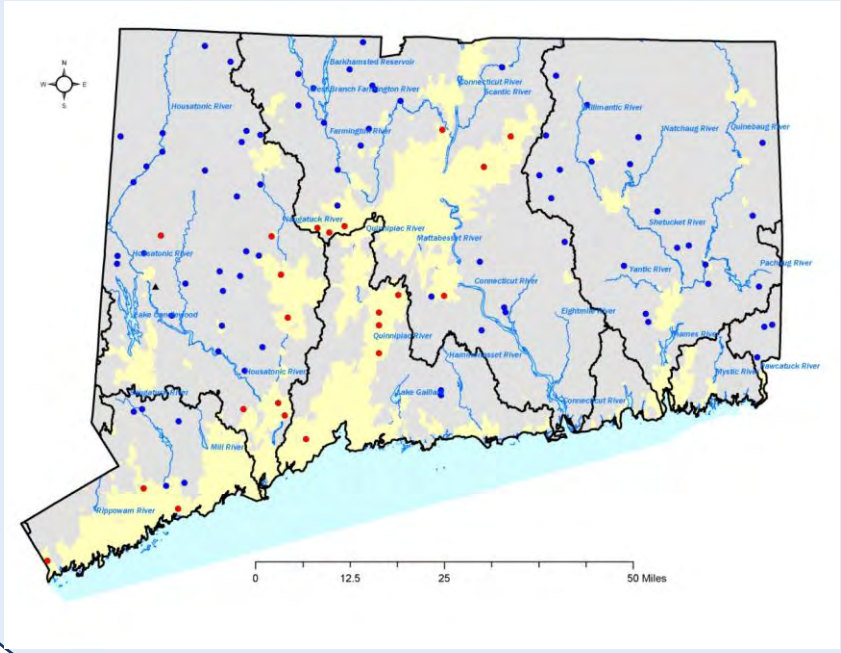


Figure 13. Statewide assessment for aquatic life use support in wadeable streams in Connecticut. Blue circles are fully supporting, red circles are not supporting, and black triangles have insufficient information to make an assessment of recreation. Yellow shaded polygons are all basins > 12 % impervious cover and grey shaded basins have < 12 % impervious cover.

Water Column Chemistry

Overview: As part of the rotating basin strategy a single discrete grab sample is collected just prior to both fish community (summer) and macroinvertebrate community (fall) sampling. These grab samples are intended to represent "ambient" or "normal" conditions and not to evaluate "run-off" of other "worst-case" water quality conditions. Samples are submitted to UConn Center for Environmental Sciences and Engineering (CESE) for analysis of up to 15 parameters including general chemistry (alkalinity, hardness, pH, chloride, calcium, magnesium, total solids, total suspended solids, and turbidity) as well as nutrients (nitrogen and phosphorous constituents).

In this section several of the key parameters will be summarized. This summary includes a brief description about a water quality parameter, the water quality standard (if applicable), any implications to water quality, and a table of summary statistics, box plot, and map of the median value for each station as compared to statewide quartiles.

Chloride

Description: Naturally occurring in all waters from mineral sources but may be augmented via human sources including, road de-icing, agricultural purposes, sewage, and industrial purposes.

Numeric Criteria: 860 ppm acute criterion, 230 ppm chronic criterion
http://www.ct.gov/dep/lib/dep/water/water_quality_standards/wqs_final_adopted_2_25_11.pdf

Implications: Elevated levels can result from permitted discharges, non-point sources, and storm water run-off. Values above 860 ppm may be detrimental to aquatic life (acute criterion) while values above 230 ppm may impact organism growth and survival (chronic criterion). Typically, ambient data from Connecticut streams do not exceed these values.

Results: Chloride is reported as parts per million (ppm). Statewide chloride levels are usually between 12 and 36 ppm. Values rarely exceed 100 ppm and those that do may be indicative of some type of human enhancement. Chloride appears to be similar in all major basins except for basin 7 where values tend to be higher (Figure 14, 15 and Table 7).

DEEP Project Highlight- TMDL Chloride Study

DEEP had been conducting studies to develop procedures to identify stressors likely causing aquatic life impairments in streams (Stressor ID Program). With road salt applications increasing over the past 60 years (Mattson and Godfrey 1994), the potential exists for increased in-stream chloride concentrations. Chloride has been identified as an important stressor to aquatic life in other states; New Hampshire and Illinois developed chloride Total Maximum Daily Loads (TMDLs). With funding from an EPA Section 104(b)(3) grant, the Department began a two year study to examine in-stream chloride concentrations in select streams across the state and enhance the Stressor ID program.

YSI 600 XLM multi-parameter probes were deployed at six stream locations beginning in October 2009 and remained deployed for 12 months to collect specific conductance and water temperature data. Specific conductance was used as a surrogate measure of chloride concentrations in the water. Quality control checks were performed with separate multi-probes upon deployment, data upload/maintenance, and retrieval. Grab samples were collected monthly during probe upload/maintenance. Benthic macroinvertebrate samples were collected during fall 2009 and fall 2010.

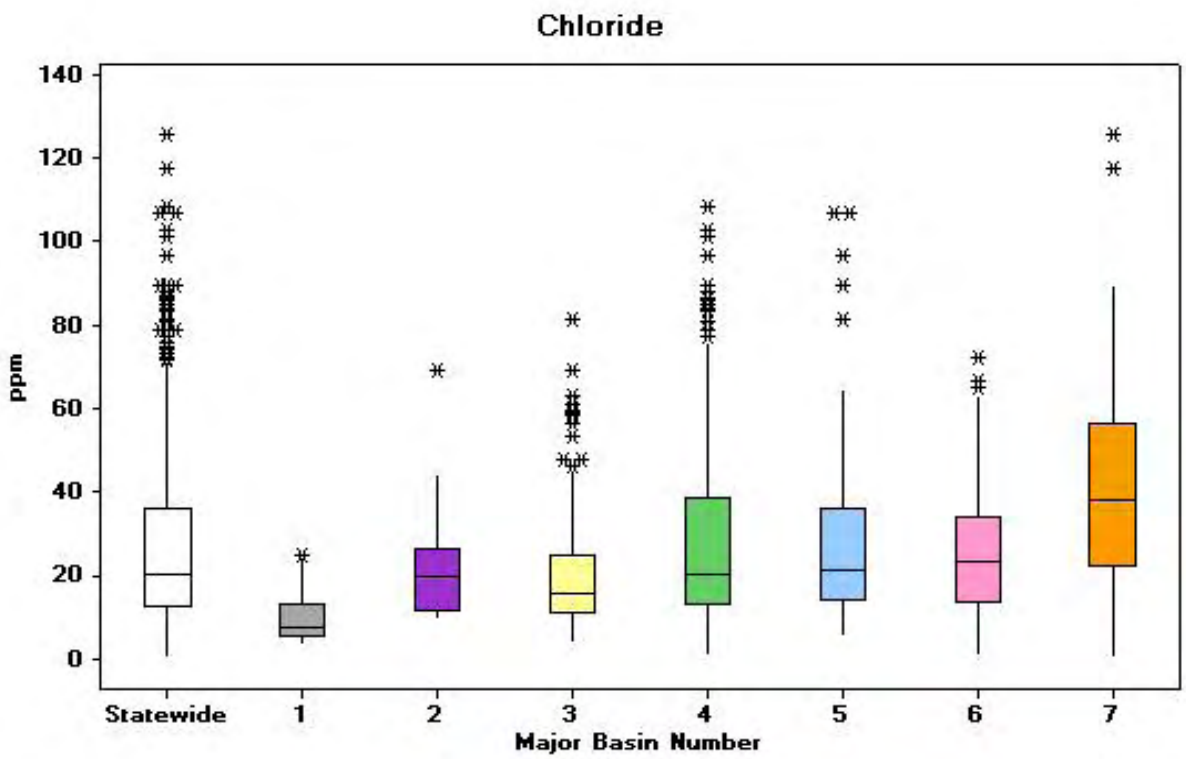


Figure 14. Box plot by major basin of chloride for samples collected in support of the rotating basin strategy 2006-2010

Table 7. Chloride concentrations for samples collected 2006-2010 in support of the rotating basin strategy.

Statistics	Statewide	Major Basin Number						
		1	2	3	4	5	6	7
Count	963	26	15	200	346	113	173	90
Minimum	0.2	3.5	9.6	3.7	0.8	5.5	0.7	0.2
Q1 (25th percentile)	12.5	5.6	11.75	10.83	13.02	13.98	13.45	22.07
Mean	26.29	9.81	23.41	19.65	28.01	28.58	23.74	41.7
Median	20.2	7.2	19.5	15.45	20.2	21.43	23	37.8
SE Mean	0.63	1.22	4.13	0.96	1.15	1.96	1.09	2.48
StDev	19.68	6.21	15.99	13.50	21.45	20.79	14.33	23.49
Q3 (75th percentile)	36	13.18	26.5	24.95	38.73	35.75	34.05	56.5
Maximum	125.8	24.6	69.1	81.2	108.2	106.8	72	125.8

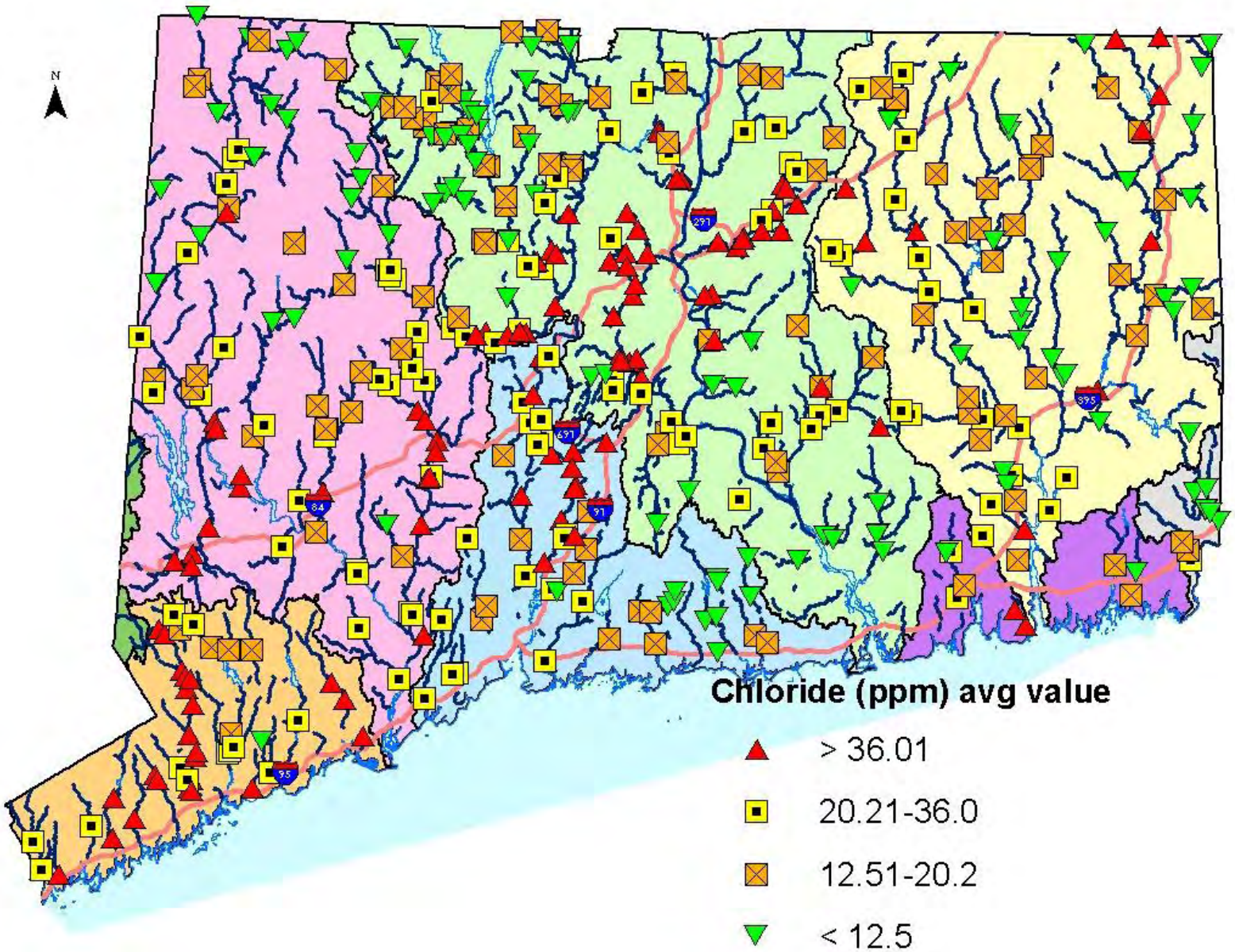


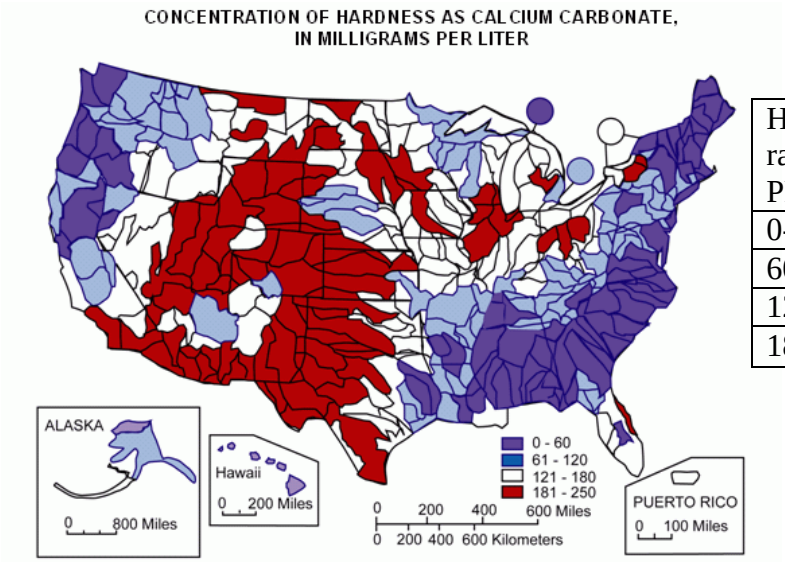
Figure 15. Distribution of chloride data (average of samples) at sites sampled for the 2006-2010 rotating basin strategy.

Description: Hardness is a physical property derived primarily from dissolved calcium and magnesium coupled with bicarbonate and carbonate, sulfates, chlorides, and other anions and trace cations. Those on private well water may be familiar with hardness, as water that is too hard can prevent detergents from being effective and can leave a "scale" behind. Often a water "softener" may be used to reduce hardness. The backwash from these softener systems contain chloride and can act as a human source to the environment.

Numeric criterion: None

Implications: In general hardness has minimal direct impacts to aquatic life, but is an important measure of water quality because it is related to the effect of toxics on aquatic organisms. The toxicity due to dissolved metals usually increases with decreasing hardness.

Figure 16 below shows typical hardness ranges across the country. Connecticut happens to be split down the middle with soft to slightly hard in the Connecticut River valley and moderately hard water in both eastern and western portions of the state.



Hardness range in PPM	Hardness Classification
0-60	Soft
60-120	Moderately Hard
120-180	Hard
180+	Very Hard

Figure 16. Hardness levels across the United States. This figure is from the United States Geologic Survey, http://water.usgs.gov/owq/hardness-alkalinity.html. The unit of milligrams per liter is directly equivalent to parts per million.

Results: Hardness is reported as parts per million calcium carbonate (ppm $CaCO_3$). In general since hardness is primarily related to the underlying rock formation, values tend to increase dramatically from southeastern Connecticut (Basins 1 & 2) with sandy coastal soils and granitic bedrock to very high levels in Northwestern Connecticut with limestone bedrock (Basins 6&7) [Figure 17, 18 and Table 8]. Overall, river and stream water is considered to be "slightly too moderately hard". When compared to the rest of the country, Connecticut is at the soft end of the scale.

Hardness

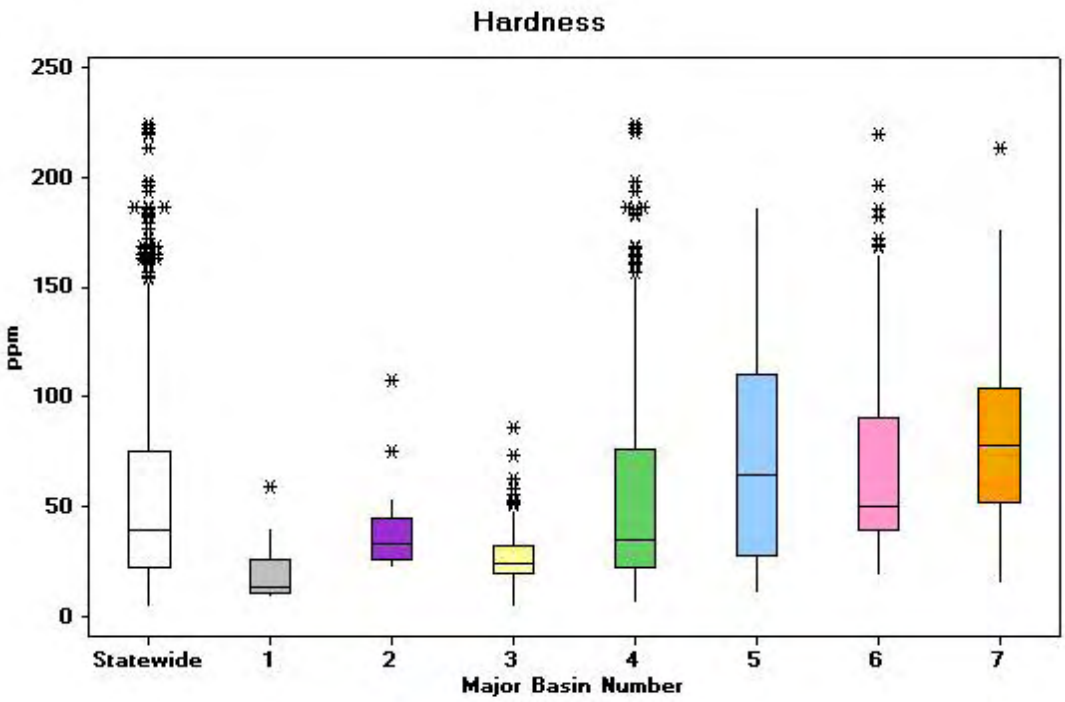


Figure 17. Box plot by major basin of hardness concentrations for samples collected in support of the rotating basin strategy 2006-2010.

Table 8. Selected summary statistics for hardness concentrations for samples collected in support of the rotating basin strategy 2006-2010.

Hardness Statistics	Statewide	Major Basin Number						
		1	2	3	4	5	6	7
Count	955	26	15	197	346	109	173	89
Minimum	4.1	8.5	22.38	4.1	5.7	11	18.41	15
Q1 (25th percentile)	22.6	10.75	26.2	19.3	22	28	39.73	51.65
Mean	55.09	19.65	39.99	27.40	55.66	69.42	69.75	81.08
Median	39.2	13.75	32.8	24	34.85	64	50	77.55
SE Mean	1.4	2.52	5.97	0.89	2.53	4.24	3.4	3.75
StDev	43.18	12.87	23.11	12.492	47.06	44.25	44.7	35.36
Q3 (75th percentile)	74.8	25.7	45	31.7	75.63	110.45	90.36	103.5
Maximum	224	58.7	107	86	224	186	219	213

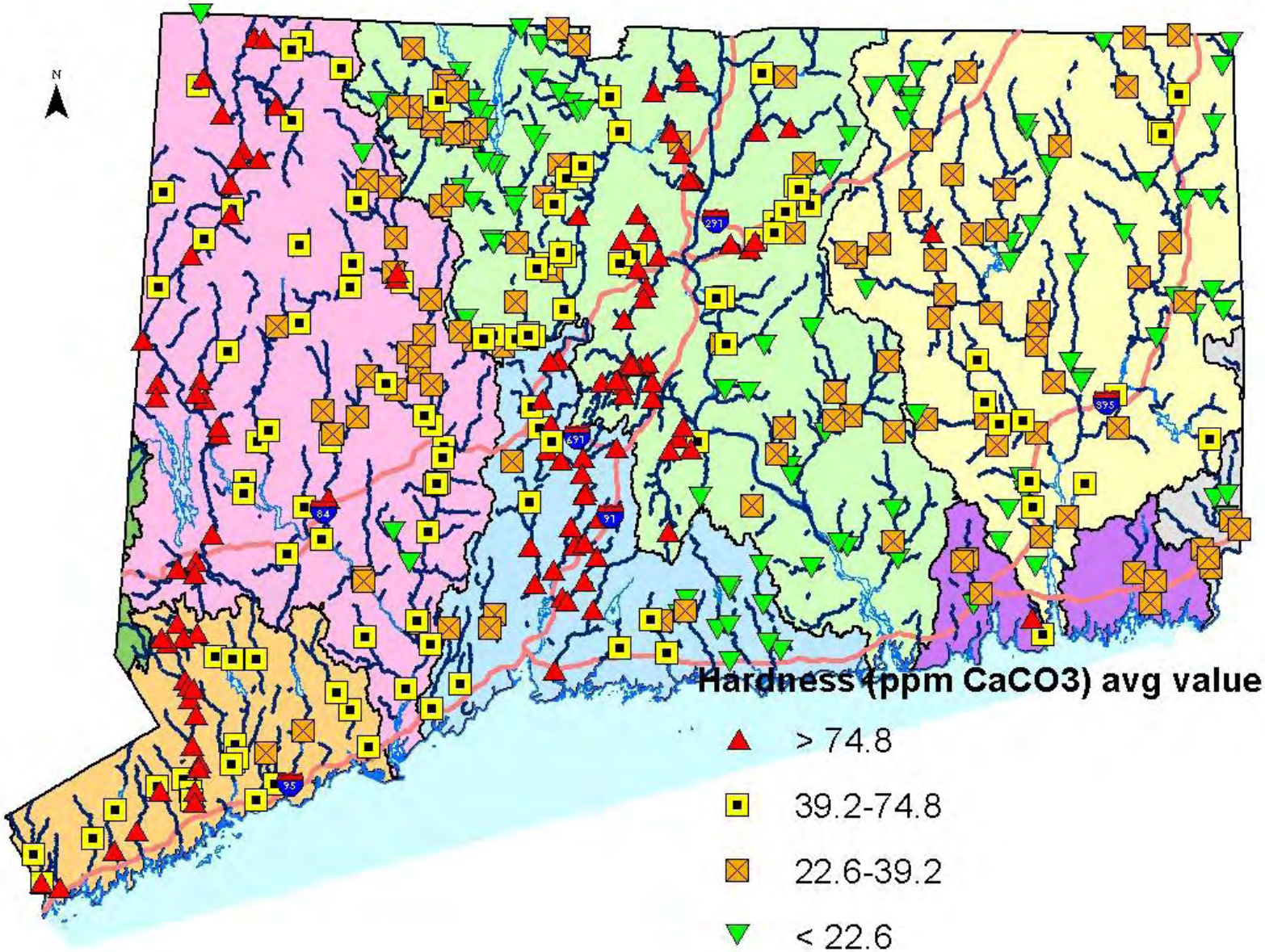


Figure 18. Distribution of hardness data (average of samples) at sites sampled in support of the rotating basin strategy 2006-2010.

Total Nitrogen

Description: The sum of inorganic and organic nitrogen species.

Narrative criteria: The loading of nutrients, principally phosphorus and nitrogen, to any surface water body shall not exceed that which supports maintenance or attainment of designated uses

Implications: Nitrogen occurs both naturally and is augmented by human activities such as wastewater treatment, agricultural application, and atmospheric deposition due to combustion of fossil fuels. High levels of ammonia, one of the nitrogen species, can be toxic to aquatic life. Nitrogen is a nutrient but does not cause significant nuisance algae blooms in freshwater systems. Nitrogen is a limiting factor for marine waters and can be and as such it is the focus of inland water quality management activities to reduce loading to the Long Island Sound. High levels in LIS are the cause of hypoxia in the western end of the sound.

Results: Total nitrogen is reported in parts per million as nitrogen. Ambient total nitrogen levels should be low. Those above 1 ppm usually indicate some sort of human source to the waterbody. Unlike hardness, nitrogen is not related to underlying geology and does not have a gradient across the state. "*" indicated on the box plot are probably related to monitoring locations on significant waste-receiving streams. Compared across the state, streams in the central valley (major basins 4 and 5) tend to have the highest values (Figure 19, 20 and Table 9).

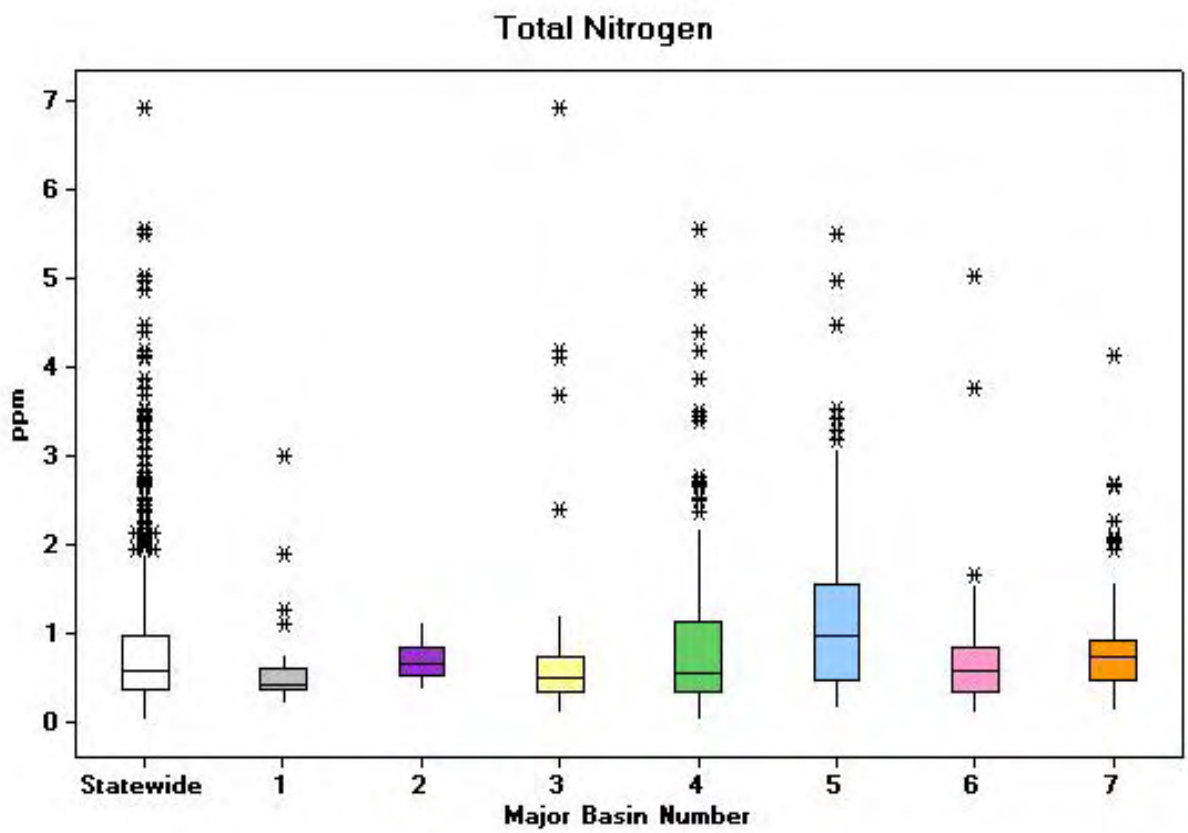


Figure 19. Box plot by major basin of total nitrogen concentrations for samples collected for samples collected in support of the rotating basin strategy 2006-2010.

Table 9. Selected summary statistics for total nitrogen concentrations samples collected for samples collected in support of the rotating basin strategy 2006-2010.

Total N Statistics	Statewide	Major Basin Number						
		1	2	3	4	5	6	7
Count	963	26	15	200	346	113	173	90
Minimum	0.008	0.191	0.348	0.1	0.008	0.157	0.09	0.131
Q1 (25th percentile)	0.352	0.355	0.522	0.3345	0.328	0.4615	0.327	0.4573
Mean	0.7986	0.638	0.6829	0.6273	0.8355	1.22	0.6543	0.8512
Median	0.571	0.411	0.636	0.4945	0.5485	0.971	0.571	0.733
SE Mean	0.0243	0.118	0.0578	0.0486	0.0423	0.0957	0.041	0.0655
StDev	0.7551	0.6	0.2238	0.6876	0.7867	1.0174	0.5387	0.6211
Q3 (75th percentile)	0.97	0.598	0.83	0.7358	1.1205	1.5315	0.836	0.9218
Maximum	6.93	2.994	1.111	6.93	5.55	5.49	5.035	4.13

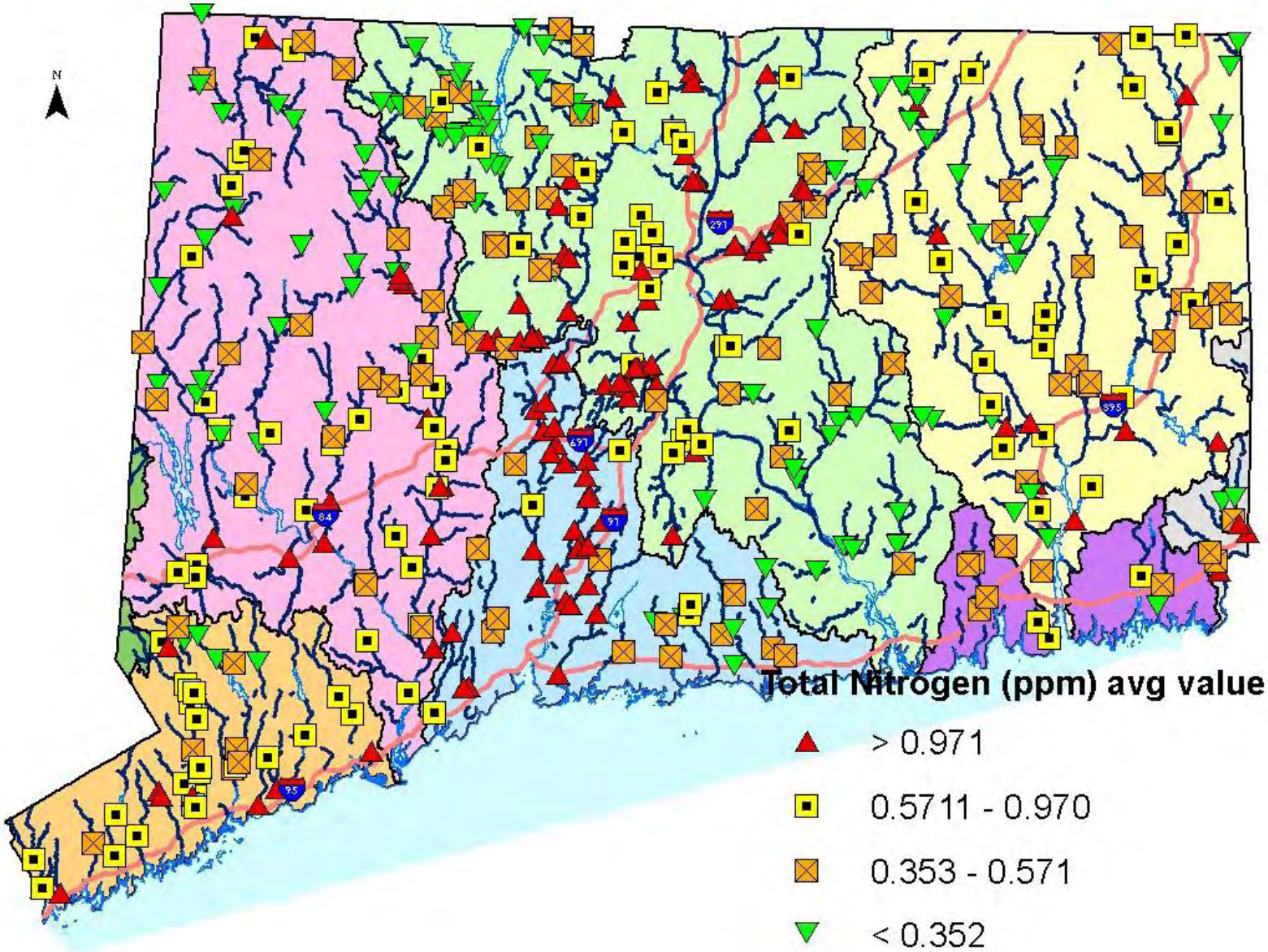


Figure 20. Distribution of total nitrogen data (average of samples) at sites sampled in support of the rotating basin strategy 2006-2010.

Total Phosphorous

Description: Phosphates can occur naturally due to mineral leaching and are augmented by human activities such as wastewater and industrial discharges, and agricultural applications.

Narrative criteria: The loading of nutrients, principally phosphorus and nitrogen, to any surface water body shall not exceed that which supports maintenance or attainment of designated uses.

Implications: Unlike nitrogen, phosphorous can be the limiting factor for primary production in freshwater systems. Elevated levels combined with moderate retention time can cause nuisance algal blooms, turning many lakes, ponds, and riverine impoundments "pea-soup" green. In streams excess phosphorous may lead to thick mats of algae on the stream bottom.

Results: Total phosphorous is reported in parts per million as phosphorus. Total phosphorous concentrations vary naturally in Connecticut and are found in very low levels, measured in the thousandths of ppm. "*" indicated on the box plot are probably related to monitoring locations on significant waste-receiving streams, especially in basins 4-6. Similar to total nitrogen, when compared across the state, streams in the central valley (major basin 4 and 5) tend to have the highest values (Figure 21, 22 and Table 10).

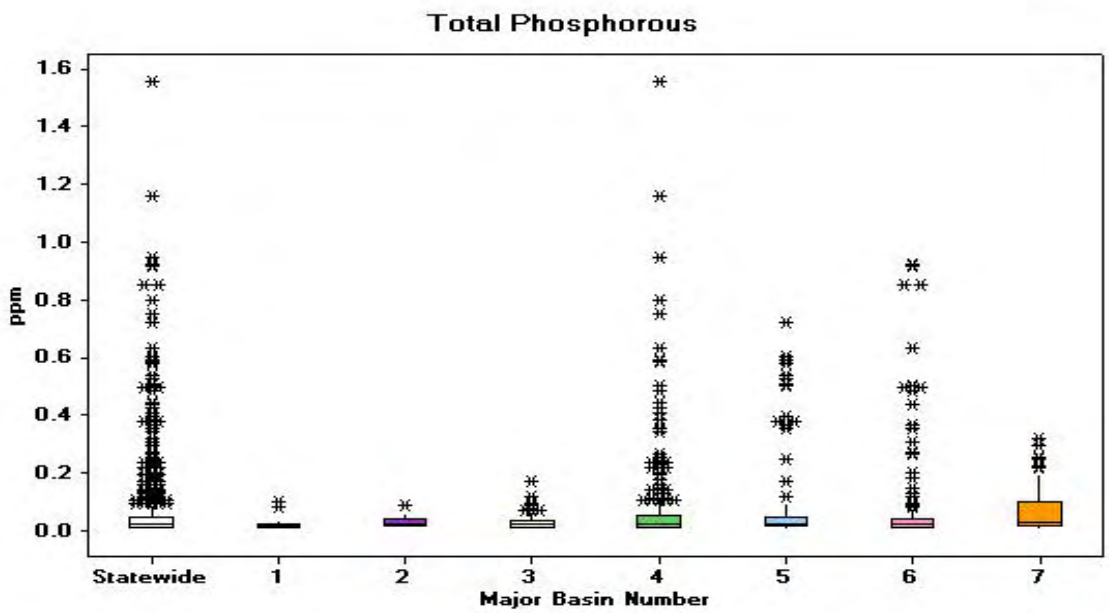


Figure 21. Box plot by major basin of total phosphorous concentrations for samples collected in support of the rotating basin strategy 2006-2010.

Table 10. Selected summary statistics for total phosphorous concentrations samples collected in support of the rotating basin strategy 2006-2010.

Total Phosphorous Statistic	Statewide	Major Basin Number						
		1	2	3	4	5	6	7
Count	963	26	15	200	346	113	173	90
Minimum	0.002	0.003	0.009	0.003	0.002	0.003	0.002	0.003
Q1 (25th percentile)	0.012	0.01	0.013	0.011	0.011	0.014	0.012	0.01775
Mean	0.060	0.021	0.030	0.025	0.067	0.091	0.073	0.068
Median	0.021	0.017	0.024	0.0195	0.02	0.022	0.019	0.03
SE Mean	0.004	0.004	0.006	0.001	0.008	0.015	0.012	0.008
StDev	0.132	0.022	0.022	0.021	0.155	0.163	0.163	0.073
Q3 (75th percentile)	0.043	0.023	0.037	0.033	0.048	0.048	0.039	0.097
Maximum	1.558	0.1	0.089	0.17	1.558	0.722	0.922	0.315

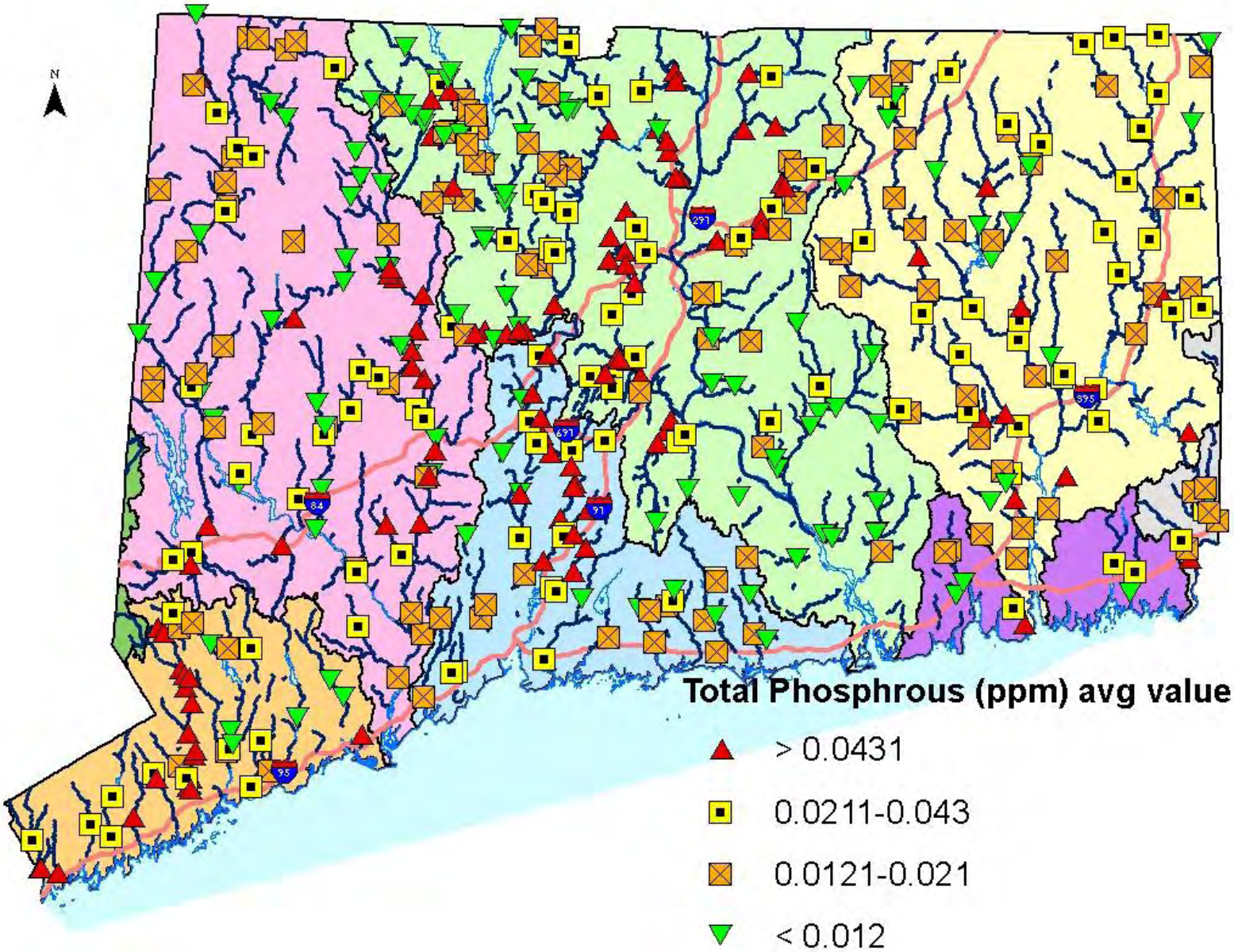


Figure 22. Distribution of total phosphorous (average of samples) at sites sampled in support of the rotating basin strategy 2006-2010.

Turbidity

Description: The degree light is scattered when projected through the water column. All suspended material including, fine sediments, microorganisms, and fine organic matter can contribute to turbidity. High quantities of suspended material will result in a high turbidity. Turbidity can depend upon the underlying geologic formation. Waters flowing through soft and highly-erodible bedrock will have higher values than streams flowing over granite.

Numeric criterion: Not to exceed 5.0 NTU over background.
http://www.ct.gov/dep/lib/dep/water/water_quality_standards/wqs_final_adopted_2_25_11.pdf

Implications: Can decrease the amount of light available for photosynthesis. When related to suspended solids high turbidity can indirectly result in decreased habitat quality and stress to the gills of aquatic organisms.

Results: Turbidity is reported in NTU- Nephelometric Turbidity Unit. In general stream waters should be clear, and therefore have very low turbidity. Values statewide tend to be less than 2-3 NTU. Values above 10 NTU represent conditions where human activities may have resulted in decreased water quality. Suspended algae also contribute to turbidity and streams with high productivity due to nutrient loading will have greater turbidity (Figure 23, 24 and Table 11).

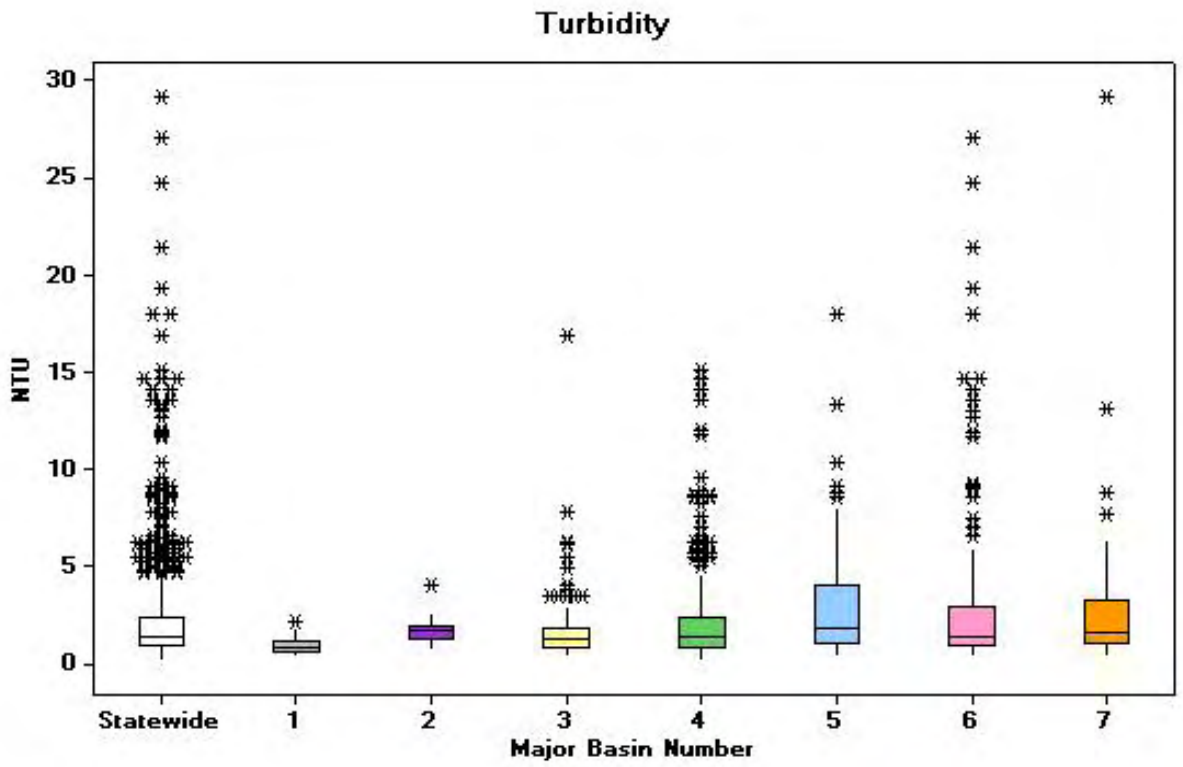


Figure 23. Box plot by major basin of turbidity concentrations for samples collected in support of the rotating basin strategy 2006-2010.

Table 11. Selected summary statistics for turbidity concentrations samples collected in support of the rotating basin strategy 2006-2010.

Turbidity Statistics	Statewide	Major Basin Number						
		1	2	3	4	5	6	7
Count	963	26	15	200	347	113	173	89
Minimum	0.1	0.3	0.7	0.3	0.1	0.3	0.3	0.4
Q1 (25th percentile)	0.9	0.6	1.2	0.8	0.8	1.05	0.9	1
Mean	2.27	0.94	1.73	1.52	2.09	2.92	3.10	2.67
Median	1.3	0.8	1.7	1.2	1.3	1.83	1.3	1.6
SE Mean	0.093	0.085	0.219	0.107	0.122	0.265	0.34	0.374
StDev	2.891	0.434	0.848	1.519	2.271	2.820	4.471	3.526
Q3 (75th percentile)	2.4	1.125	1.9	1.8	2.4	4.04	2.95	3.2
Maximum	29.2	2.1	4	16.9	15.1	18	27.1	29.2

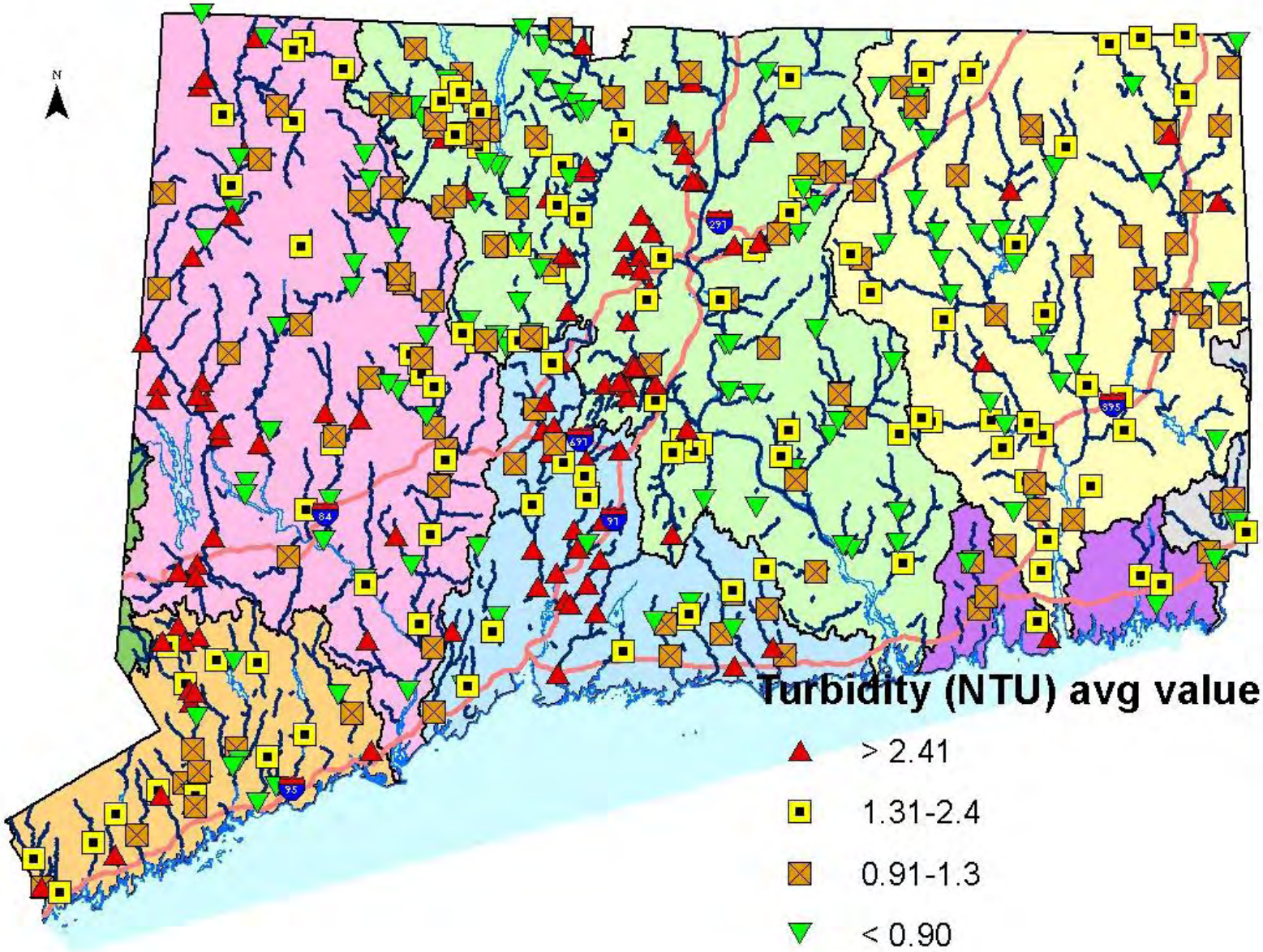


Figure 24. Distribution of turbidity data (average of samples) at sites sampled in support of the rotating basin strategy 2006-2010.

Water Temperature

Overview: Water temperature varies daily, weekly, and seasonally. To capture the magnitude and duration of this variability continuous logging temperature probes are programmed to capture data every hour. Water temperature can also vary longitudinally from headwaters to mouth. Key variables that influence water temperature include elevation, canopy cover, gradient, and quantity of groundwater input. Water temperature is a very important to organisms as it can drive chemical reactions and physiological activity.

Reporting unit: Degrees Celsius (Fahrenheit)

Description: Water temperature is a primary variable for determining which species of fish are able to in habitat a particular section of stream. Three categories were used to describe water stream temperatures in this report following Lyons and others (2009) and are summarized below (Table 12).

Table 12. Water temperature thresholds for three habitat types described by Lyons and others 2009.

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

Numeric criteria: There shall be no changes from natural conditions that would impair any existing or designated uses assigned to this Class and in no case exceed 85 ^{o}F (29.4 ^{o}C), or in any case raise the temperature of surface water more than 4 ^{o}F (2.2 ^{o}C).
http://www.ct.gov/dep/lib/dep/water/water_quality_standards/wqs_final_adopted_2_25_11.pdf

Implication: All three water temperature categories naturally occur within Connecticut streams. Water temperature categories can vary longitudinally within a stream network. Human activities like damming and permitted thermal discharges may influence water temperature regime by both increasing (surface releases and groundwater withdrawal) and decreasing (hypolimnetic withdrawal) water temperatures. To determine the magnitude of any human influence it is necessary to determine how far from natural has the stream temperature changed. This is a very difficult question to answer as data for pre-disturbance are often not available.

What was done: Water temperature probes were secured into PVC tubes and placed into a section of stream predicted to have adequate flow to keep the probe submerged. Probes were secured by a heavy iron weight and then covered with large rocks. Details regarding water temperature probe deployment can be found in the WPLR *Standard Operating Procedures for Measuring Continuous Water Temperature* (CTDEEP, 2011).

Results: Water temperature probes were deployed at 333 site locations during the 2006-2010 rotating basin time period. This level of effort was through a cooperative effort between WPLR and DEEP Inland Fisheries Division. The water temperature data are stored in a relational Microsoft Access database application and have allowed DEEP to perform many complex analyses. One type of analysis was allows one to look at key metrics like maximum temperatures as well as the duration and frequency of maximum temperatures, maximum low temperatures (the highest temperature that the stream does not drop below), and critical thresholds for various aquatic organisms (Figure 25).

A second type of analysis to classify each of the 333 sites as cold, cool and warm water habitat per Lyons and others 2009. This analysis showed 25 sites were cold water, 174 were cool water (56 were cool-cold transition, 118 were cool-warm transition), and 134 were warm water habitat (Figure 26).

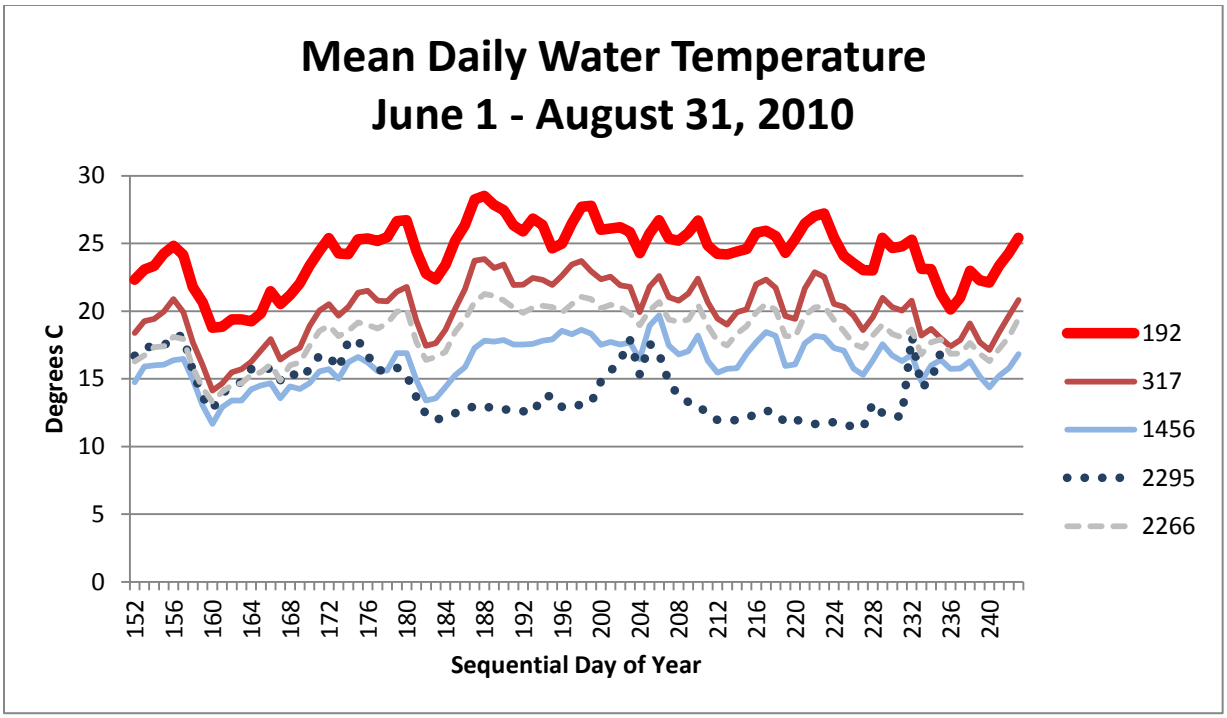


Figure 25. An example of water temperature data from 5 locations that represent the continuum of water temperature habitats in Connecticut. Warm water habitat is typical of conditions found in the Naugatuck River at Beacon Falls (192), cool water or mixed water in Sandy Brook at Robertsville (317) or in Bunnell Brook at Burlington (2266), and cold water in Bonemill Brook (1456) at Stafford or in Mott Hill Brook at Glastonbury (2295).

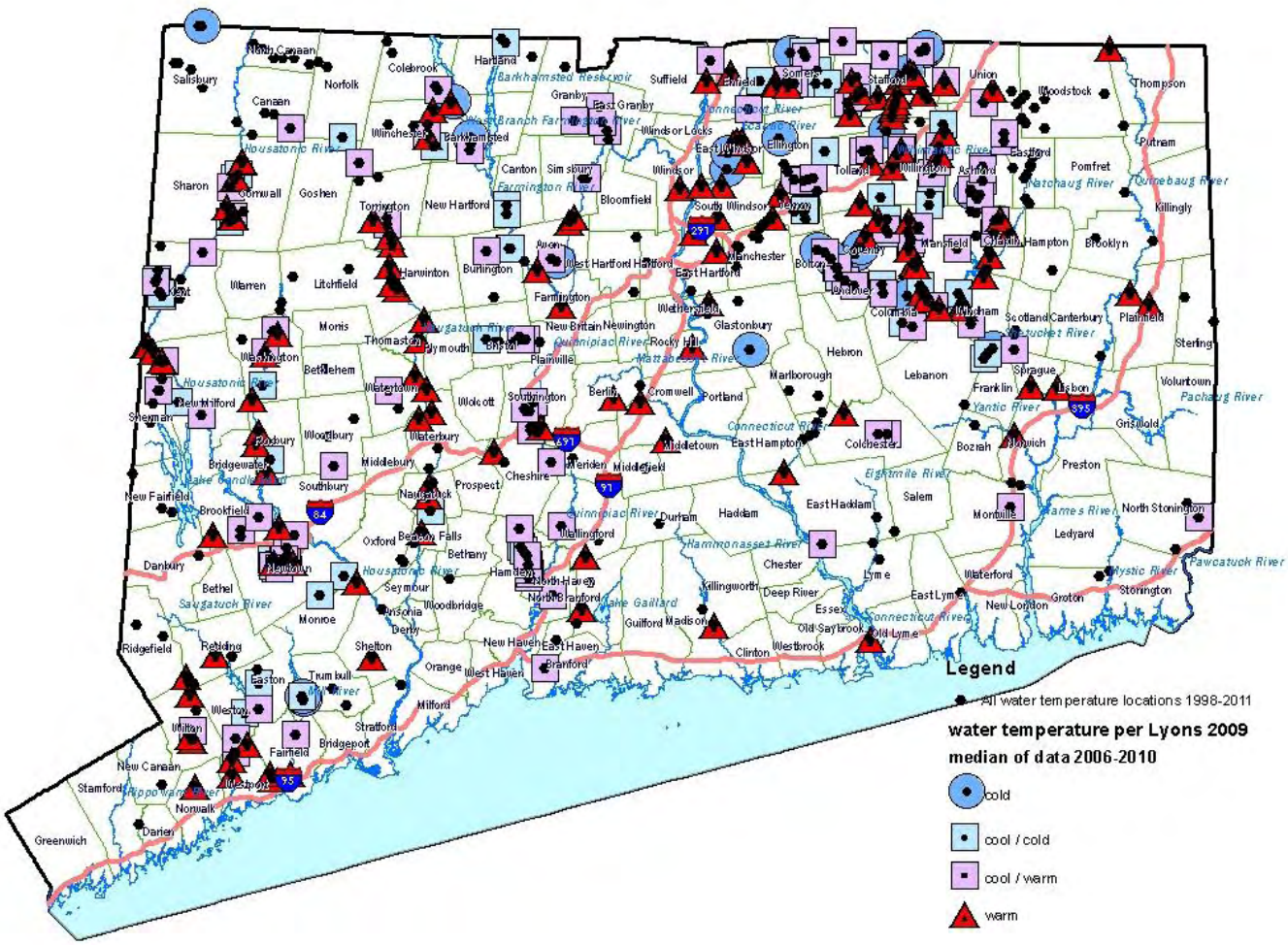


Figure 26. Distribution of 333 measured water temperature versus habitat classification defined by Lyons and others 2009 during the 2006-2010 rotating basin strategy. Circles indicate cold water, squares transition between both cold and warm, and triangles indicate warm water habitat. The small black dots represent locations where water temperature data have been collected but are outside of the 2006-2010 time frames.

Citizen-Based Water Quality Monitoring

Overview: Citizen-based monitoring is an integral component to Connecticut's water quality monitoring program. While generating credible water quality data these citizens by default act as stewards and ambassadors of natural resource management in the local setting. These data are used to inform local policy makers about environmental conditions in their town and in-turn used to make educated land-use and policy decisions. Citizen-based monitoring is the foundation for developing an environmental educated and literate citizenry.

Since 1999, DEEP has promoted a 3-tiered approach to citizen-based monitoring as described in detail at http://www.ct.gov/dep/cwp/view.asp?a=2719&q=325608&depNav_GID=1654 , and has reached over 2,500 volunteer citizens in the program (Figure 27). A description of each of the tiers in presented in Table 13 and a brief summary of each with a side bar highlighting a representative citizen-based program follows.

Figure 27. The number of volunteers who participated in the tier 2 RBV program each year since the program inception in 1999.

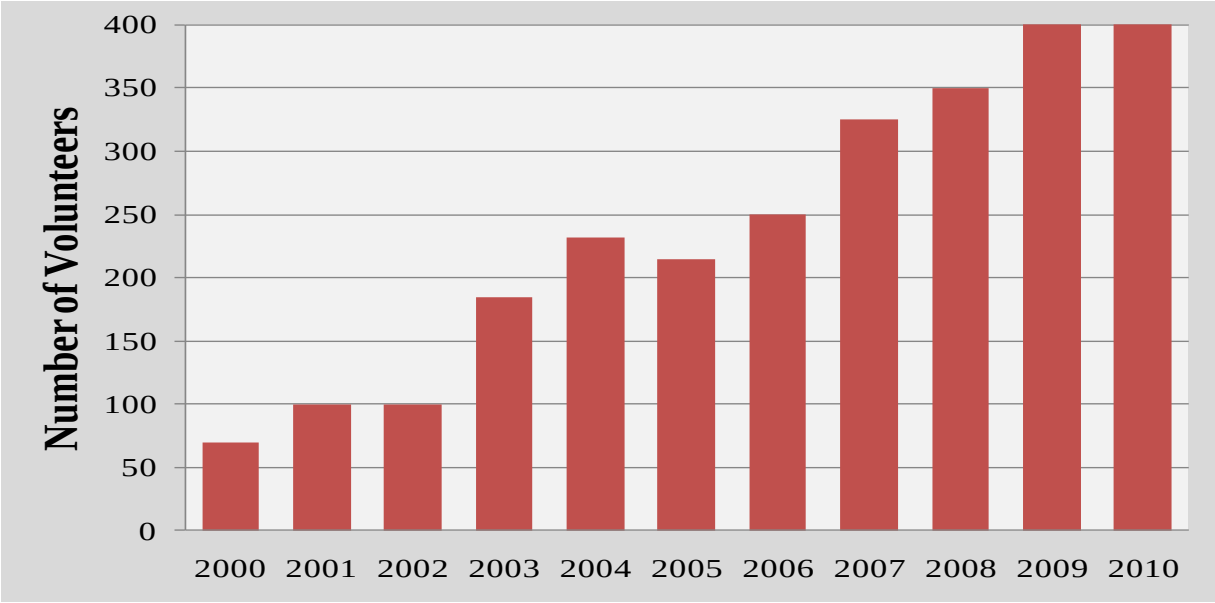
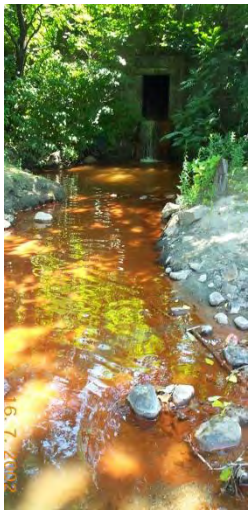


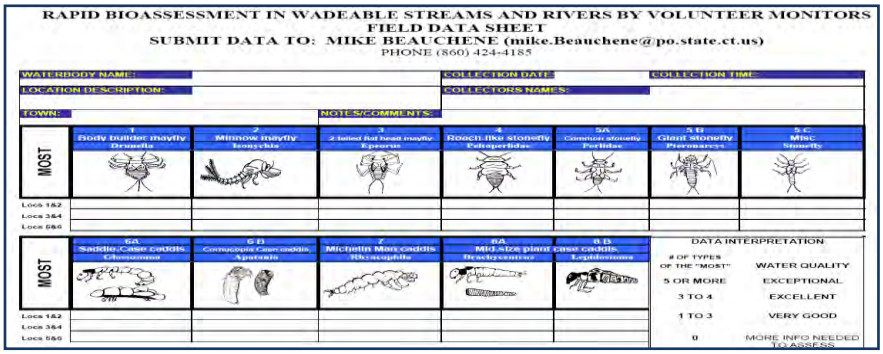
Table 13. A summary of key attributes about the 3 tier citizen-based monitoring system recommended by WPLR.

Tier	Time Investment	Training	Types of Issues	Types of Information Collected
1	Minor, but persistent, many little bits of time may be necessary to capture an episodic event.	Little but will need to know what type of documentation to submit.	Episodic events like, sewage overflow, poor sediment and erosion control, effluent upsets, illegal discharges, dumping	Digital photos, written description of activities, email and or phone calls to appropriate parties involved. May not involve DEEP, may be at a local level only.
2	Minor to Moderate 1 day /year	Formal training at a sponsored event	Documents places with either very high or very low water quality. Not very informative for medium water quality.	macroinvertebrate community data
3	Significant Several days per week or month, seasonal or year round	Follows a formal Quality Assurance Quality Control Project Plan	Ambient conditions, quantification of a parameter, criteria exceedance or support, TMDL assistance.	Indicator bacteria, chemical, temperature, macroinvertebrate community

TIER 1: The first tier, observational monitoring, is low-technology and does not require many resources. The premise is based on the fact that many current water quality issues are short-term episodic events. The successful resolution of these events is related to the length of time that passes prior to detection. A network of eyes on the water enables a more rapid detection when a short-term episodic event is ongoing. Quick and immediate notification of proper authorities usually brings closure to the event.



TIER 2: Rapid Bioassessment in wadeable streams and rivers (RBV) is the second tier (www.ct.gov/dep/rbv). Similar to WPLR macroinvertebrate monitoring efforts, RBV focuses on collecting macroinvertebrates from riffle habitat within a stream or river. However, instead of focusing on the entire macroinvertebrate community, RBV essentially is a scavenger hunt for a subset of organisms that can be found. RBV participants are especially focused on finding the "most wanted". Those macroinvertebrates "most wanted" are indicative of good water quality.


RAPID BIOASSESSMENT IN WADEABLE STREAMS AND RIVERS BY VOLUNTEER MONITORS
FIELD DATA SHEET
SUBMIT DATA TO: MIKE BEAUCHENE (mike.Beauchene@po.state.ct.us)
PHONE (860) 424-4185

WATERBODY NAME: | COLLECTION DATE: | COLLECTION TIME:
LOCATION DESCRIPTION: | COLLECTORS NAMES:
TOWN: | NOTES/COMMENTS:

	1 Body builder mayfly Drunella	2 Minnow mayfly Isonychia	3 2 lobed flat head mayfly Epeorus	4 Roach like stonefly Peltoperlidae	5A Common stonefly Perlidae	5 B Giant stonefly Pteronarcys	5 C Misc Stoneflies
MOST							
Locs 1&2							
Locs 3&4							
Locs 5&6							

	6A Saddle Case caddis Glossosoma	6 B Cornucopia Case caddis Agapetus	7 Michetlis Mark caddis Rhyacophila	8A Mid-size plant case caddis Brachycentrus	8 B Lightbrown Leptodemma
MOST					
Locs 1&2					
Locs 3&4					
Locs 5&6					

DATA INTERPRETATION

# OF TYPES OF THE "MOST"	WATER QUALITY
5 OR MORE	EXCEPTIONAL
3 TO 4	EXCELLENT
1 TO 3	VERY GOOD
0	MORE INFO NEEDED TO ASSESS

Over the past five years the RBV program continues to grow both in the number of sites annually as well as the total number of participants. The primary output from the RBV program are samples containing four or more "most wanted" types. Samples that meet this criterion are considered to represent full support of WPLR aquatic life water quality standards. Those with fewer than four are not automatically considered for water quality assessments but usually require additional follow-up to obtain a definitive water quality assessment.

Results: During the 2006-2010 time frame citizens collected samples at 267 sites. Eighty-three of these sites (31%) had at least four different types of the "Most Wanted" (Figure 28). At these 83 locations WPLR were able to provide an assessment for aquatic life as "Full Support" for the IWQR. Without many of these locations, water quality conditions would remain unassessed.

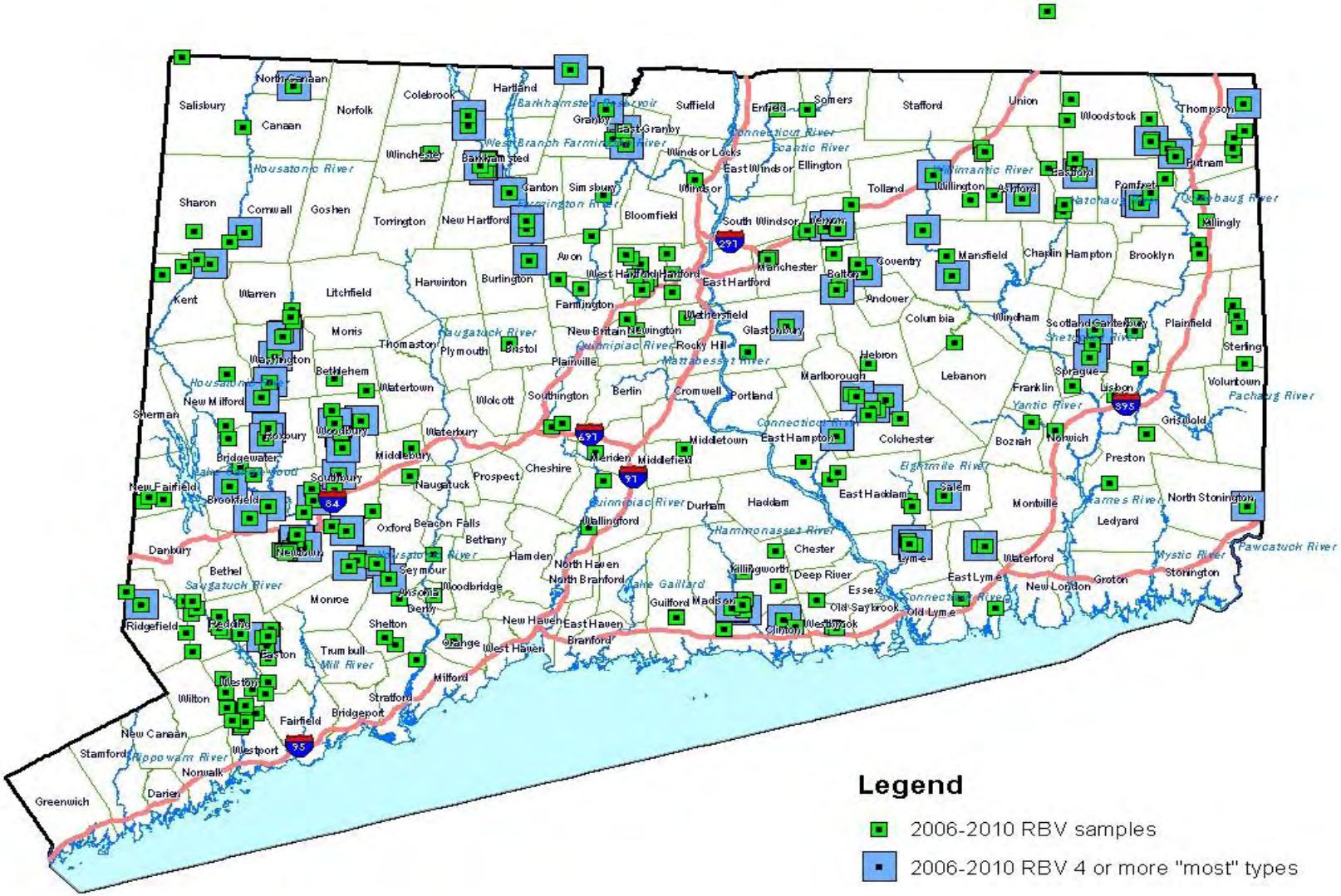


Figure 28. The location of 267 samples collected by citizens participating in the RBV program between 2006-2010. The large square represents samples with 4 or more "most wanted" types were present in the sample.

DEEP Project Highlight- Q & A with 2 RBV programs:

The Nature Conservancy-Saugatuck River Watershed Partnership, Respondent, Sally Harold (SH)

http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/connecticut/placesweprotect/the-saugatuck-river-watershed-partnership.xml

The Nature Conservancy-Salmon River Watershed Coalition, Respondent, Shelly Green (SG)

http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/connecticut/placesweprotect/salmon-river.xml

What is your primary driving force behind getting involved with water quality monitoring? SH- TNC is working to protect and enhance the health of the Saugatuck River Watershed. Water quality monitoring enables us to identify areas of concern, document changing conditions, engage the public in a citizen science project and provides us with an opportunity to talk about our efforts basin wide.

SG- Although the subwatersheds in the Salmon are generally healthy, altered water quality was identified as a primary threat to its long-term health. We expect to be tracking longer term trends as more development occurs.

What is or has been the monetary cost of this work? SH & SG-Each year we invest time in preparing materials for volunteers, printing maps and directions, scouting the sites, reserving a room and coordinating our sampling days. We have had Mike conduct the training on one of the two sampling days. TNC has led the training on the 2nd day. We also offer coffee and doughnuts during the training. An estimate of cost per day (including the trainer's time) and our volunteer intern's time preparing materials is $350/day.

About how many people participate through your program?
SH- Our program began hosting the RBV program in 2004 with 7 volunteers surveying 4 sites. Last fall we had over 100 volunteers and we surveyed 20 sites (over two days)

SG- Last year 60 people participated.

How have you been able to use your data at the local level? We are compiling this data and comparing it with temperature and other water quality data that has been collected over the same time frame from the same sites to get a clearer picture of the conditions in the rivers. We anticipate completing our first major analysis of this data set by this fall.

What is/are some of your highlights while doing this type of work? SG & SH-The enthusiasm of volunteers for this project has been especially rewarding. Many high school students participate and they've told their teachers this is their favorite class activity. Being able to describe watershed threats such as increased impervious cover or low stream flow don't mean as much to people until they understand the communities that might be affected and how these communities are important to watershed health. The teams are inspired to look hard for the most wanted! Mike has made it easy for us.

TIER 3: The third tier, a formalized monitoring program, is the most labor intensive. This type of monitoring requires an approved quality assurance/quality control plan, as well as lots of time and effort to collect, process, and analyze sample data. Data collected include indicator bacteria, water column chemistry, and water temperature. Major contributors of this type of data are Earthplace, Westport, Connecticut, Farmington River Watershed Association, Simsbury, Connecticut, Eastern Connecticut Conservation District, Trout Unlimited, Candlewood Valley Chapter, and The Nature Conservancy at Devils Den Preserve.

Water Temperature Monitoring: Thanks to support provided via the US EPA volunteer monitoring equipment loan program three organizations have been able to assist WPLR with annual ambient water temperature monitoring. Each of the three groups place a probe at several sites of interest in April/May and collect them the following October. The probes record water temperature once an hour for the entire deployment period. These data have been very instrumental with water quality standard development, fish habitat assessment, and potential stream habitat restoration (Figure 29).

DEEP Project Highlight- Q& A with a volunteer temperature monitoring group

Trout Unlimited-Candlewood Valley Chapter (CVTU) http://cvtu.org/, Respondent: Joe Hovious

What is your primary driving force behind getting involved with water quality monitoring? Looking at impacts on the local fishery and water quality here in Newtown. The Town of Newtown, Pootatuck Watershed Association, and Candlewood Valley Trout Unlimited all have a vested interest in evaluating and maintaining water quality.

What is or has been the monetary cost of this work? Costs were to acquire equipment like Hobo temperature monitoring probes and a rainfall/temperature gage. CVTU has purchased 14 probes and a rainfall monitor for a total of about $2200. A variety of grants have been used to purchase this equipment and all labor is provided via volunteers. It would be very difficult if not impossible to do this effort without the support of DEEP staff. While we have common goals, giving support has been a necessary part of the effort

How have you been able to use your data at the local level? Data have been used in presentations to local Inland Wetlands and Planning and Zoning officials and have had significant impact on projects which might impact local waters. A much greater sensitivity to local cold water resources has resulted in many areas. At least in some cases developers have sought information on temperature protective measures in project planning.

What is/are some of your highlights while doing this type of work? Having real data to impact proposed projects which could impact local resources. Getting involvement with local land use planning staff. A scholarship award for students working with macroinvertebrate monitoring has been a highlight.

What is/are: some major frustrations while doing this type of work? Learning temperature monitoring software. Lost or non functioning temperature probes. Weather impacting sampling and/or probe recovery. Getting busy volunteers out to events can be an issue. It takes a lot of time for participants.

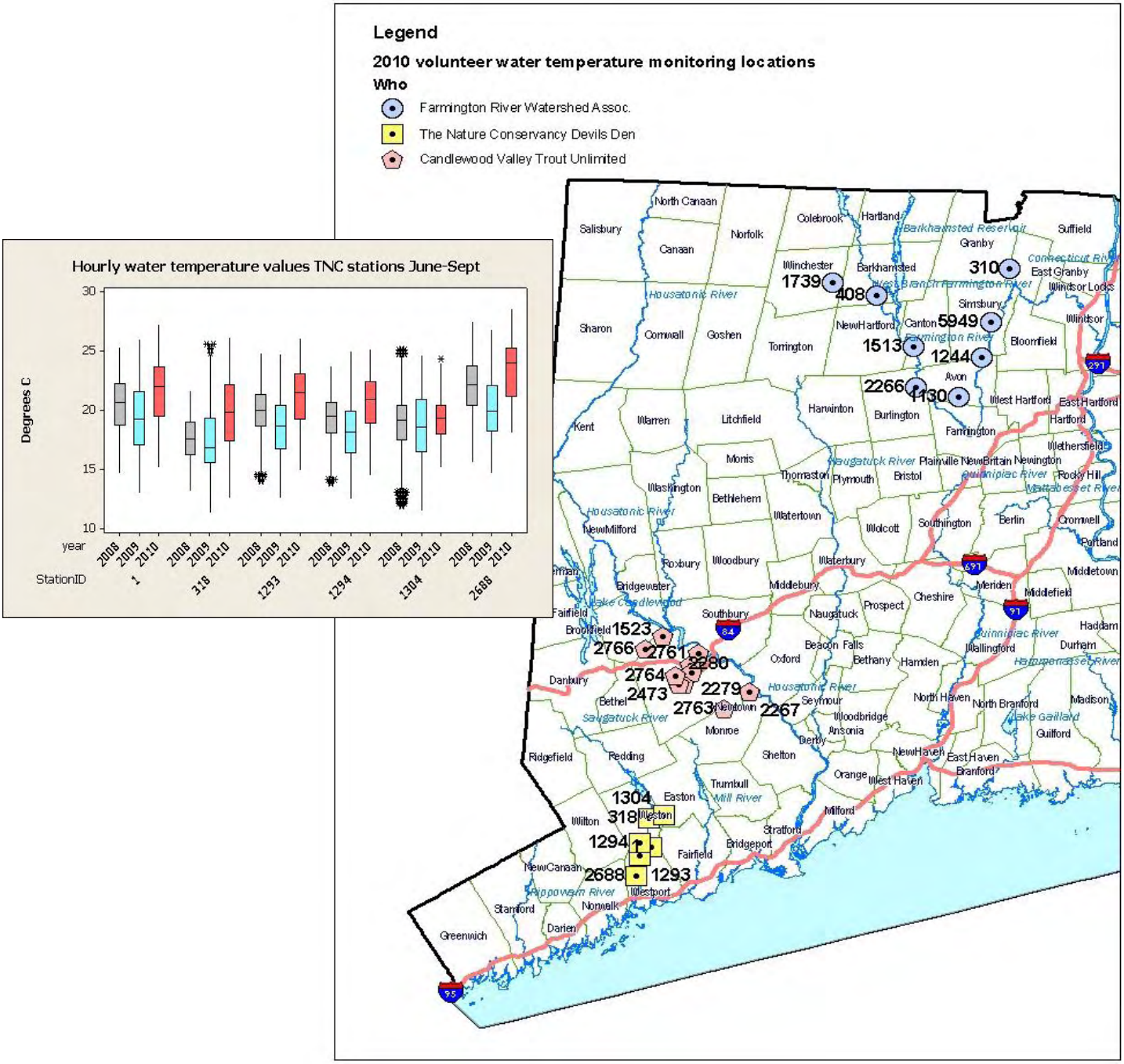


Figure 29. Deployment location of water temperature data collected by 3 citizen-based programs that have deployed USEPA loaned water temperature probes during 2008-2010 with an example box plot to show the distribution of June-September water temperatures at the same 8 stations over 3 consecutive years.

Water column including chemistry and or bacteria- Collection and analysis of water samples for a variety of parameters is very resource demanding and in most cases expensive. Several very dedicated programs have been successful at finding both human and monetary resources to collect and analyze hundreds of water quality samples over the past five years. Data submitted to WPLR from these programs have been used in our contact recreation assessments in support of Federal Clean Water Act goals as well as to support TMDL development and implementation.

One such group is Earthplace in Westport, CT. Under the supervision of Richard Harris and Peter Fraboni volunteers have been actively collecting water quality data for over 25 years. They operate their environmental laboratory under EPA certification and maintain the highest analytical standards. To date they have collected data from the Norwalk River, Sasco Brook, Fivemile River, Aspetuck River, West Branch Saugatuck River, Saugatuck River, and many small tributaries toe each of these mainstem water bodies. Without the dedicated effort of Dick at Earthplace, water quality in Fairfield County would be much less than it is today. Thanks Dick and Pete!

DEEP Project Highlight- Q&A with a Tier 3 Water Chemistry Sampling Program

The Farmington River Watershed Association, Respondent, Alisa Philips-Griggs
http://www.frwa.org/

What is your primary driving force behind getting involved with water quality monitoring? The Farmington River Watershed Association seeks to integrate principles and practices of river and watershed protection with specific local water quality monitoring in order to better understand our river, specific water quality threats, and potential mitigations. Our work also increases the Farmington River Watershed data available to DEEP and helps focus resources on our watershed. Our chemical sampling in the upper Farmington River in Connecticut is one aspect of our multifaceted water quality program to monitor trends in our river and tributaries.

Who are your partners and or funders? The Farmington River Coordinating Committee (FRCC), overseers of the Wild & Scenic section of the river, funds our upper Farmington River (Connecticut) water quality monitoring and the Metropolitan District (MDC) donates laboratory analysis of chemistry/metals/bacteria for this project.

About how much do you think the cost of the project is/was? It is not possible to separate the cost of this project out from other assessment in the upper watershed, however FRCC gives us $15,000 for assessment, MDC in-kind is valued at $15,375, and volunteer in-kind is valued at $4,200.

About how many people participate through your program? We have many volunteers contributing to our overall monitoring program but the upper Farmington River chemical monitoring runs efficiently with just two teams of two sampling fifteen sites on the river and tributaries monthly from April through November. Additionally, several people work to perform the laboratory analysis donated by the MDC.

How have you been able to use your data at the local level? We use our data to track our healthy waters and identify which tributaries are contributing specific pollution sources to the river, and our monitoring data helps inform our restoration projects. In addition, we share our data with the FRCC, MDC, DEEP and other local entities.

What is/are some of your highlights while doing this type of work? We literally have our finger on the pulse of the river; we are in direct contact with the river and can observe the river dynamics and ecosystem up close. Our monitoring program interconnects us with other researchers in the field such as the MDC, DEEP, USGS, and other watershed organizations and provides a springboard to engage with kayakers, anglers and other river users.

Indicator Bacteria

Overview: Indicator bacteria (http://www.epa.gov/region1/eco/beaches/qa.html) sampling involves the collection of surface water in a sterile container. Each sample is placed on ice and transported to the Connecticut Department of Health (CT DPH) Environmental Services Microbiology Laboratory for analysis. For freshwaters, *Escherichia coli* (*E. coli*) are used as a surrogate for the presence of pathogenic (disease-causing) organisms like viruses, bacteria, and protozoan. These organisms are usually the cause of mild to severe gastroenteritis, ear infections, and in more severe cases hepatitis and cholera. The criteria used to evaluate the sanitary quality of a waterbody using the *E. coli* results is based upon USEPA research and the relationship between indicator bacteria levels and the number of bathers who became ill following swimming (USEPA 1986).

Parameter*:* *Escherichia coli (E. coli)* as Colonies Forming Units (CFU)/ 100 ml

Description: A bacteria found in the digestive system of all warm blooded animals that is used as an indicator of fecal contamination. *E. coli* can enter the environment through the feces from waterfowl, wildlife, pets, and farm animals as well as through treated sewage, failing septic systems, illegal sewer hookups and storm water run-off.

Numeric criteria*:* Varies depending upon the designation of the water body. The criteria are more protective for designated and non-designated swimming areas than those that are not designated for bathing (See State Bathing Beach Section). For freshwater, non-bathing areas, the maximum single sample value is 576 CFU/100 ml (colony forming unit), and a maximum geometric mean of 126 CFU/100 ml. http://www.ct.gov/dep/lib/dep/water/water_quality_standards/wqs_final_adopted_2_25_11.pdf

Implications: *E. coli* data are collected and used to determine the sanitary quality of the water being tested. As these bacteria are often found in the same location with human pathogens, and they are easy to grow in the laboratory, they make for a good surrogate to determine the potential for the presence of human waste material. High levels may indicate the presence of human fecal material that may contain pathogens. Low levels do not mean that pathogens are absent and care should always be taken not to ingest untreated surface water. *E. coli* data are difficult to interpret on their own and often require additional investigation via sanitary surveys by trained professionals to determine the source.

What was done: Starting in 2006, WPLR began to sample approximately 60 stations that were selected as part of the New England Wadeable Stream Project (NEWS) facilitated by USEPA Chelmsford Environmental Laboratory. This process used a hexagon based weighted monitoring design for probabilistic site selection. It was later determined that the GRTS method was more appropriate for determining statewide assessments and the ambient monitoring program adopted the approach in 2010. The data presented below represents samples collected between 2006 and 2009 using the original hexagon based design and the 63 locations sampled in 2010 (Figure 30). Approximately 11 samples were collected from each site location during the five years resulting in over 4,000 bacteria data points. In 2010 based on recommendation from US EPA Corvallis, a new set of sites was selected using the GRTS method. These 63 sites were sampled 10 times during 2010 and are used for our statewide contact recreation assessment (see *Contact Recreation Statewide Estimate via Probabilistic Monitoring 2010* **below**).

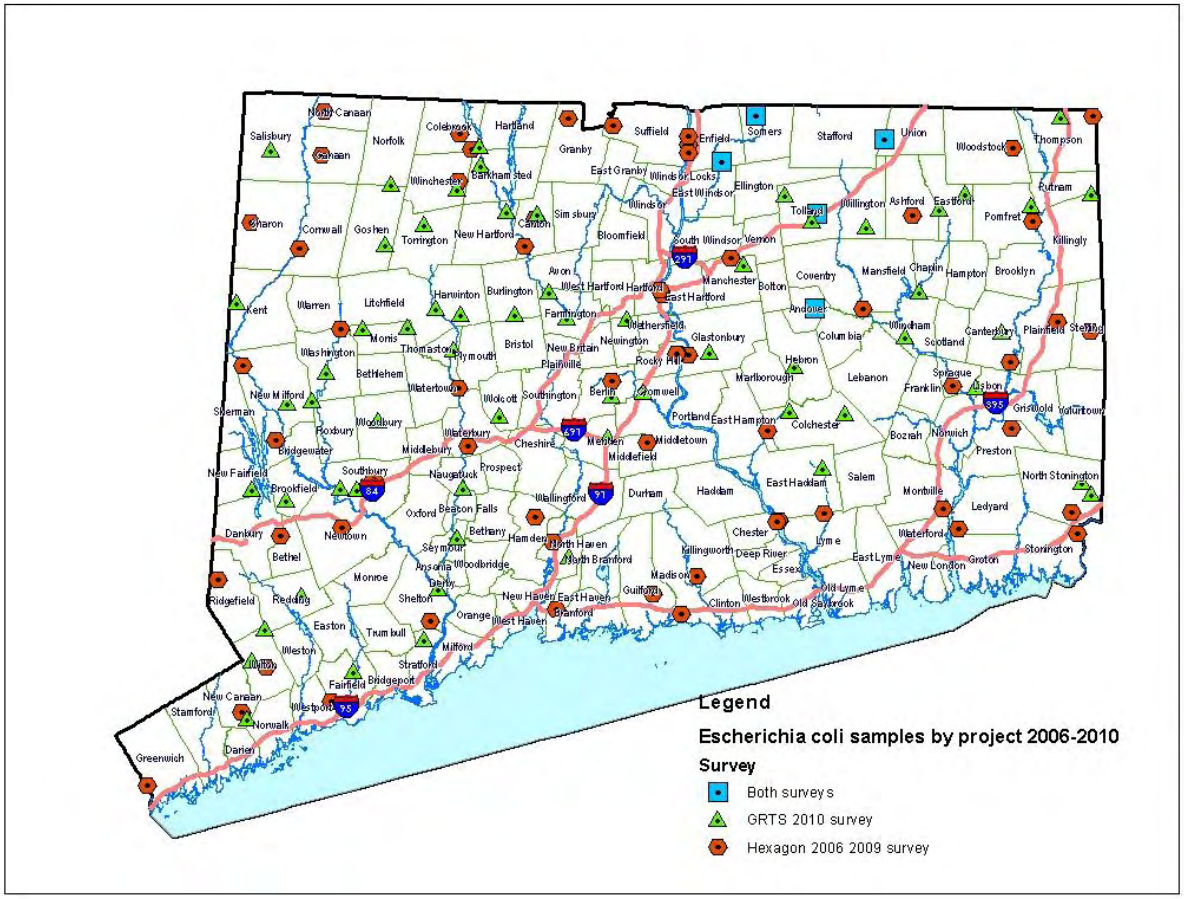


Figure 30. The location of randomly selected stations used for indicator bacteria sampling during 2006-2010. There were two different projects-one using a hexagon-based system from 2006-2009 and the second the GRTS design where any point on any stream has equal probability as another of being selected. A few locations were selected for both surveys.

Results: Values can range from < 10 to > 24,000 CFU/100 ml (Figure 31 and Table 14). In general *E. coli* can be found anywhere at any time and as such there is no clear pattern statewide. Values above 1,000 CFU/100 ml may be indicative of a human source of *E. coli*. Stations with multiple samples with very high levels tend to have a sanitary issue that needs to be resolved.

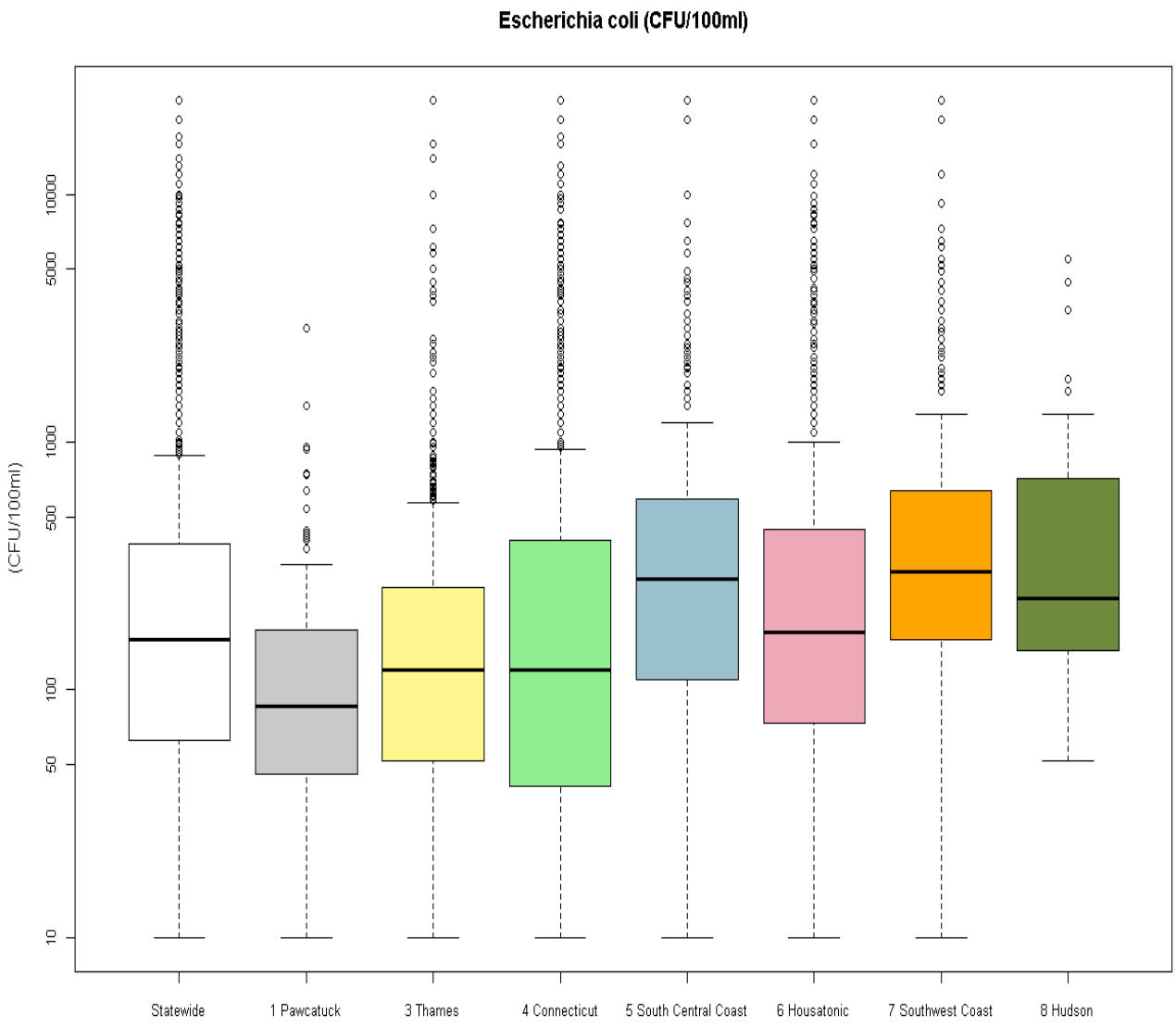


Figure 31. Box plot by major basin of E. coli values by major basin for samples collected between 2006-2010.

Table 14. Select summary statistics for E. coli for samples collected between 2006-2010.

E. coli Statistics	Statewide	Major Basin Number						
		1	3	4	5	6	7	8
Count	4235	119	1001	1492	354	928	293	48
minimum	<10	<10	<10	<10	<10	<10	<10	52
Q1 (25th percentile)	63	41	52	41	110	73	160	143
mean	691	185	354	780	799	828	1026	685
median	160	86	120	120	280	170	300	235
Standard Deviation	2333	334	1415	2600	2020	2694	2932	1103
Q3 (75th percentile)	390	180	260	400	590	448	645	755
maximum	>24000	2900	>24000	>24000	24000	>24000	24000	5500

Tissue Contaminants

Overview: Monitoring of toxic contaminants in tissues of fish and invertebrates has been conducted since the late 1970's in cooperation with the CTDEEP Inland Fisheries Division and CTDPH Environmental Epidemiology Section. Historically, WPLR has submitted tissue samples for mercury analysis in response to limited specific requests from CT DPH to help with determination of fish consumption advisories (http://www.ct.gov/dph/cwp/view.asp?a=3140&Q=387460).

Chemical analyses are conducted under contract with the CT DPH Environmental Services or UConn CESE. The primary purpose of this monitoring has been screening for human health risk, or more intensive assessment for development of fish tissue consumption advisories for individual water bodies. Since 1985, methodologies for fish tissue samples prepared for human health risk assessment have followed United States Department of Agriculture (USDA) guidelines for edible portion. In situations where ecological risk was the primary issue, whole fish or aquatic invertebrates have been analyzed. Current methodology generally follows recent US EPA guidance (USEPA, 1995). Tissue contaminant data has also been obtained by means of State or private contractors.

The majority of information on mercury in fish tissue are from 51 Connecticut Lakes collected via 2 studies (Neumann and others, 1996; Vokoun and Perkins 2008,) or unpublished data collected as part of the Inland Fisheries statewide stream survey project 1988-1994 (WPLR memo 03/07/2011).

In an attempt to obtain more recent data on the state rivers and streams WPLR collected fish and crayfish from sites selected as part of the statewide probabilistic monitoring project and the rotating basin strategy both from 2006-2010. Crayfish were collected to establish levels as they have been found to be reliable indicators of mercury in the food web (Hothem and others, 2007; (McKee, 2009; Pennuto and others, 2005). A second major effort involving mercury was to collect crayfish from a series of sites in Danbury, within the Still River regional basin, to see if a longitudinal tissue contamination gradient could be detected in crayfish.

Parameter: Total Mercury (surrogate for methlymercury)

Reporting unit: ug/g as wet weight

Description: Mercury is a naturally occurring element found in the earth and is introduced into the environment though both natural and human facilitated activities. The mercury cycle between air, land and water is very complex. An organic form of mercury, methylmercury, has been found to be the greatest risk to human health, especially during prenatal exposure. Methylmercury is created from various inorganic mercury salts via microbial activity in wetlands, water column, and sediments. Methylmercury is readily assimilated in tissue and biomagnifies up the food chain. Since it is less costly to process samples for total mercury and

up to 95% of the mercury found in tissues is methymercury, state and federal programs often analyze for total mercury and use the methylmercury criterion to be conservative.

Guideline: 0.3 ug/g wet weight as methylmercury (USEPA 2010)

Implications*:* Exposure to mercury causes a variety of health issues. Most notably is pre-natal exposure which can cause issues with neuro-development. Any health advisories for consumption of fish tissue are made in conjunction with DEEP Inland Fisheries and the Department of Public Health (CT DPH).

Interpretation: Total mercury data can be used as a screening tool. Since mercury is ubiquitous in land, water, and air any values that are greater than 0.3 ug/g should be considered elevated and potentially re-tested for methylmercury for criterion exceedance.

What was done: Four hundred fifty-three samples were submitted by WPLR to CESE for analysis. These data were collected in support of several projects including; probabilistic monitoring, rotating basin, specific requests (DEEP Inland Fisheries, CT DPH, and the Candlewood Valley Chapter of Trout Unlimited), and legacy mercury evaluation in the Still River Regional Basin, Danbury (Figure 33).

Results*:* Total mercury values in roughly 6% of the samples for each tissue category (5.6 % fish and 5.8% crayfish) were above the 0.3 ug/g wet weight methyl mercury (CH_3Hg) EPA criterion (USEPA 2010). Almost all of the crayfish values above 0.3 ug/g wet weight were from samples collected as part of the Still River, Danbury project. Only 1 crayfish sample outside of the Still River regional basin was greater than 0.3 ug/g wet weight. Total mercury in crayfish did not appear to have a species-specific gradient (Figure 34).

Highest concentrations in fish tended to be in lake population of black bass species (largemouth and smallmouth) while stream populations of self-sustaining trout (brook and brown) tended to have very low levels. Data from 5% (5/100) of the randomly selected sites (probabilistic monitoring project) exceeded the 0.3 ug/g wet weight value. Detailed summary reports are available on the DEEP website at
http://www.ct.gov/dep/cwp/view.asp?a=2719&q=487892&depNav_GID=1654

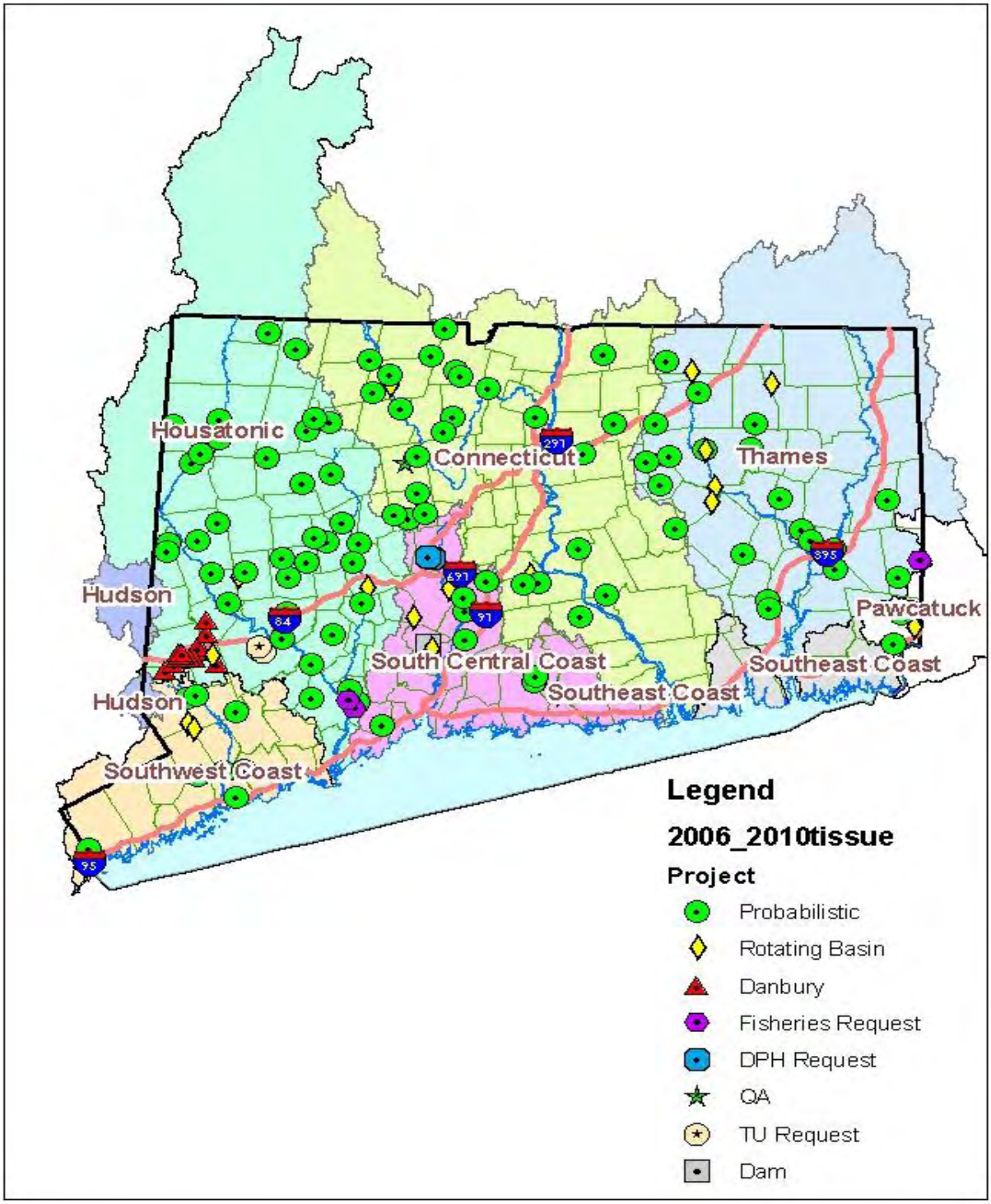


Figure 33. Locations where tissue samples were obtained and processed for total mercury by major project type during the 2006-2010 time frames.

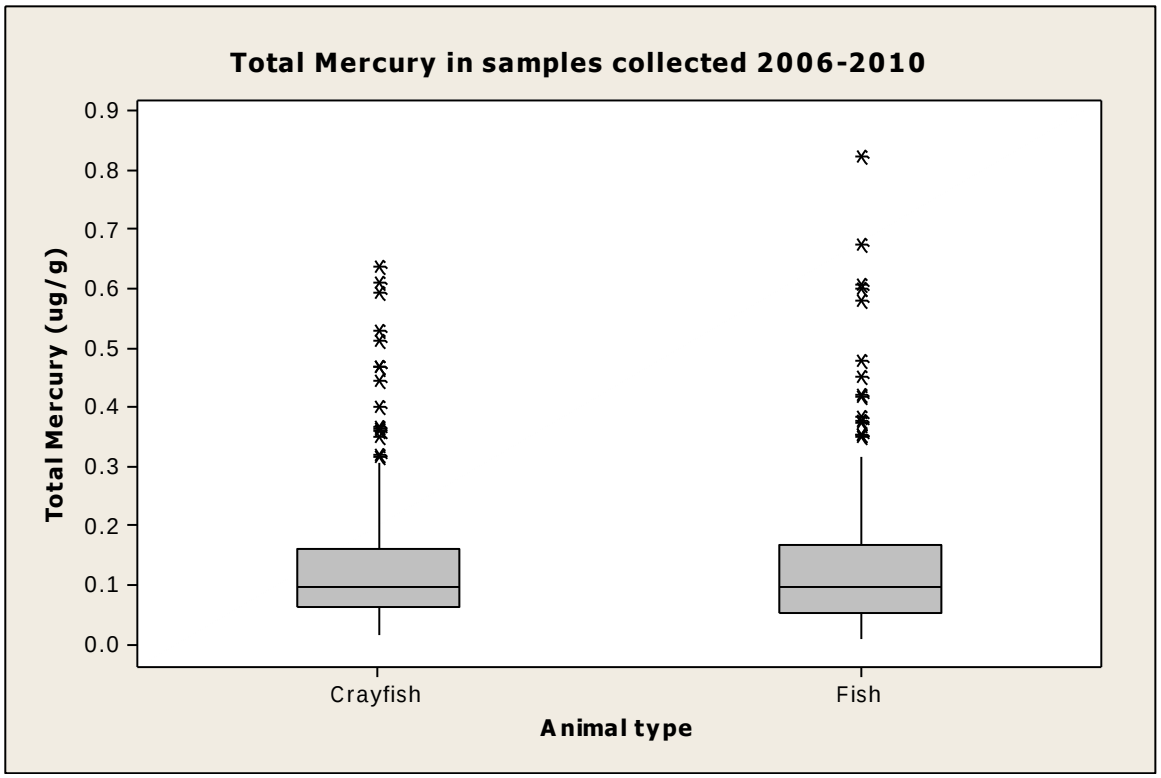
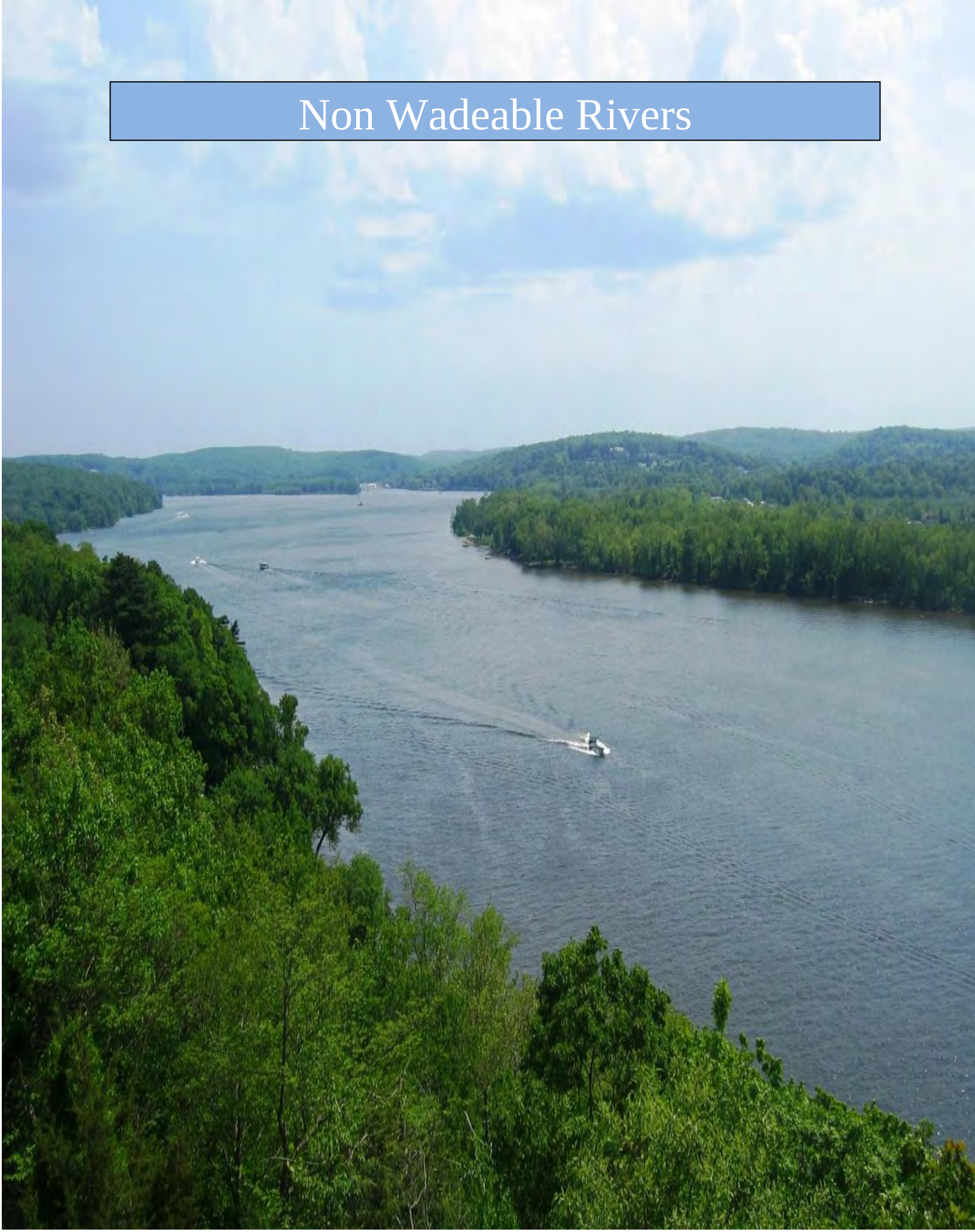


Figure 34. Box plot of total mercury data collected during the 2006-2010 time period. A conservative threshold used for guidance is 0.3 ug/g. Only a few samples in crayfish and fish were the 0.3 ug/g threshold.

Non Wadeable Rivers



Overview: The National Rivers and Streams Assessment (NRSA) was conducted in cooperation with the USEPA. The NRSA was a statistical survey of the nation's flowing waters that followed a probability based sampling design. The survey was divided into a wadeable streams assessment and a large river survey. Parameters that were measured included water chemistry, nutrients, chlorophyll-a, sediment enzymes, enterococci, fish tissue, physical habitat characteristics, and biological assessments including sampling of phytoplankton, periphyton, benthic macroinvertebrates, and fish community. Field work was performed in 2008 and 2009. Data are being validated and analyzed and a final report from EPA will be released in 2012. Connecticut opted to have an EPA contractor, Midwest Biological Institute, (MBI) conduct the field work for this survey. Additionally, MBI conducted two other surveys in Connecticut during the same time period - an assessment of the Connecticut River fish assemblage from Vermont through Connecticut and a project under the Regional Environmental Mapping and Assessment Program (REMAP) [Figure 35 and Table 15]. A comparison of the methods employed for the NRSA/REMAP and Connecticut River studies was recently presented at the 35th annual meeting of the New England Association of Environmental Biologists (NEAEB). Results of the Connecticut River Fish Assemblage Project were presented at the 33rd and 34th NEAEB meetings (See- http://www.epa.gov/region1/neaeb2009/index.html and http://www.epa.gov/region1/neaeb2010/index.html .)

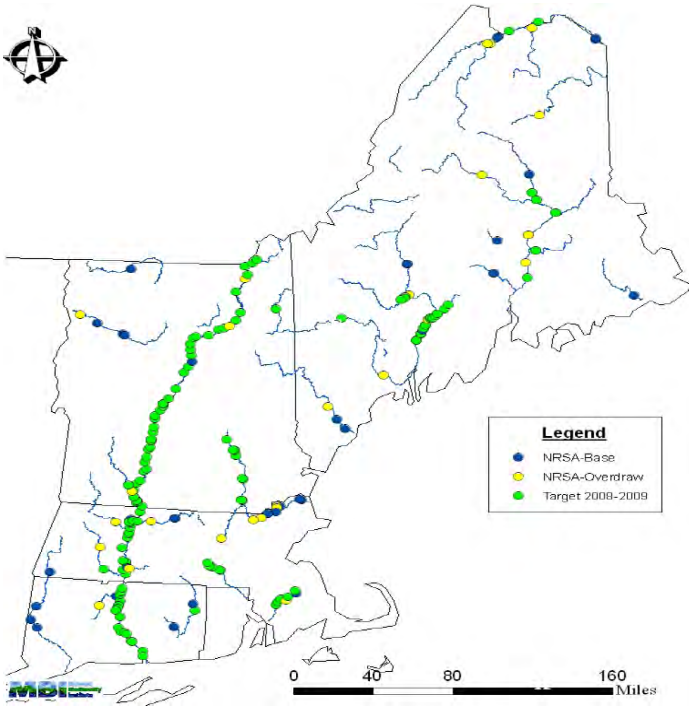


Figure 35. Map showing locations of REMAP and NRSA study sites.

Table 15. Site locations in Connecticut sampled for large rivers projects from 2006-2010.

Project	Site ID	Stream Name	Town	Date Sampled	Latitude	Longitude
CT River Fish	CTR-58	Connecticut River	Hartford	08/22/2009	41.799	-72.647
CT River Fish	CTR-58	Connecticut River	Hartford	09/21/2009	41.799	-72.647
CT River Fish	CTR-59	Connecticut River	East Hartford	08/22/2009	41.776	-72.658
CT River Fish	CTR-61	Connecticut River	East Hartford	08/22/2009	41.756	-72.658
CT River Fish	CTR-62	Connecticut River	Wethersfield	08/22/2009	41.7	-72.631
CT River Fish	CTR-63	Connecticut River	Cromwell	08/23/2009	41.594	-72.638
CT River Fish	CTR-64	Connecticut River	Middletown	08/23/2009	41.558	-72.596
CT River Fish	CTR-65A	Connecticut River	East Hampton	08/23/2009	41.549	-72.553
CT River Fish	CTR-65	Connecticut River	East Hampton	08/23/2009	41.53	-72.553
CT River Fish	CTR-66	Connecticut River	Haddam	08/24/2009	41.472	-72.483
CT River Fish	CTR-67	Connecticut River	Haddam	08/25/2009	41.466	-72.47
CT River Fish	CTR-68	Connecticut River	Essex	08/25/2009	41.371	-72.377
CT River Fish	CTR-69	Connecticut River	Old Saybrook	08/25/2009	41.334	-72.356
NRSA & REMAP	FW08CT005	Farmington River	Windsor	9/1/2009	41.891229	-72.662102
NRSA & REMAP	FW08CT006	Quinebaug River	Brooklyn	10/10/2008 & 10/6/2009	41.782704	-71.895881
NRSA & REMAP	FW08CT007	Connecticut River	Middletown	8/23/2009	41.540588	-72.551258
NRSA & REMAP	FW08CT010	Quinebaug River	Pomfret	10/10/2008	41.841008	-71.914713
NRSA & REMAP	FW08CT012	Connecticut River	Glastonbury	8/22/2009	41.710228	-72.618027
NRSA & REMAP	FW08CT014	Housatonic River	Kent	9/30/2008	41.770419	-73.430829
NRSA & REMAP	FW08CT015	Housatonic River	New Milford	9/30/2008	41.641405	-73.477794
NRSA & REMAP	FW08CT016	Farmington River	Windsor	8/31/2009	41.844477	-72.631996
NRSA & REMAP	FW08CT017	Shetucket River	Sprague	10/11/2008	41.623743	-72.088663
NRSA & REMAP	FW08CT018	West Branch Farmington River	New Hartford	9/29/2009	41.870919	-72.963733
NRSA & REMAP	FW08CT020	Housatonic River	New Milford	9/29/2008	41.574929	-73.415354
NRSA & REMAP	FW08CT021	Connecticut River	Enfield	8/20/2009	41.952095	-72.608582
NRSA & REMAP	FW08CT022	Quinebaug River	Plainfield	10/4/2009	41.675716	-71.953599

REMAP	FW08CT023	Connecticut River	Haddam	8/24/2009	41.494984	-72.518791
REMAP	FW08CT024	Pawcatuck River	North Stonington	9/2/2009	41.415481	-71.801282
REMAP	FW08CT025	Connecticut River	Wethersfield	8/22/2009	41.726164	-72.648758
REMAP	FW08CT026	Quinebaug River	Putnam	10/5/2009	41.911092	-71.913399
REMAP	FW08CT029	Shetucket River	Lisbon	no access	41.563116	-72.043207
REMAP	FW08CT032	Farmington River	Windsor	8/31/2009	41.862331	-72.647015
REMAP	FW08CT035	Connecticut River	Portland	8/23/2008	41.559944	-72.601409
REMAP	FW08CT037	Farmington River	Avon	9/30/2009	41.803237	-72.829509
REMAP	FW08CT038	Quinebaug River	Canterbury	10/4/2009	41.689751	-71.954942
REMAP	FW08CT040	Connecticut River	Portland	8/23/2009	41.617246	-72.621800
REMAP	FW08CT042	Housatonic River	Salisbury	9/17/2009	41.995990	-73.366282
REMAP	FW08CT043	Housatonic River	New Milford	9/17/2009	41.622670	-73.462255
REMAP	FW08CT045	Shetucket River	Norwich	10/6/2009	41.591761	-72.047246
REMAP	FW08CT048	Farmington River	Simsbury	9/29/2009	41.847680	-72.807561

State-owned Bathing Beaches

Overview: This program is conducted in cooperation with the DEEP Bureau of Outdoor Recreation State Parks and Public Outreach Division and two groups within CT DPH, the Environmental Health Section and the Laboratory Division, to evaluate health risks and make beach closure decisions at state-owned and managed swimming areas. WPLR personnel sample for indicator bacteria weekly at the 23 State beaches (Figure 36). Four are located along the coast of Long Island Sound, and 19 are located at inland State Parks or Forests. Water testing at state swimming areas begins the week before Memorial Day weekend and continues through Labor Day weekend. The sanitary quality of the bathing waters are determined by analyzing for the indicator bacteria *Escherichia coli* in freshwater and *Enterococci* group in saltwater. The CT DPH Laboratory Division's Microbiology Lab performs all of the indicator bacteria analyses. During the bathing season, current beach closure status is available toll free by phone at 1-866-287-2757 and on the DEEP web page at: http://www.dep.state.ct.us/updates/beach/wtrqual.asp.

Sample Collection: A total of 81 samples are collected and analyzed routinely each week as part of the bathing beach program. In addition, re-samples may be collected throughout the week as needed. A complete description of the beach monitoring program is available in the Beach Monitoring Quality Assurance Project Plan (CT-DEEP, 2009) and beach closure protocols are outlined in "Guidelines for Monitoring Bathing Waters and Closure Protocol" (CT-DPHS, 1992).

Results 2006-2010: A total of 6,402 samples were collected and analyzed between 2006 and 2010 in support of our State bathing beach monitoring program. See Table 16 for yearly and summary closure information for each State bathing area. Over the five year period, State beaches were open for nearly 98% of the bathing beach seasons. While beaches were closed for a total of 265 days, this represents 2.2 % of the bathing beach season over the five years.

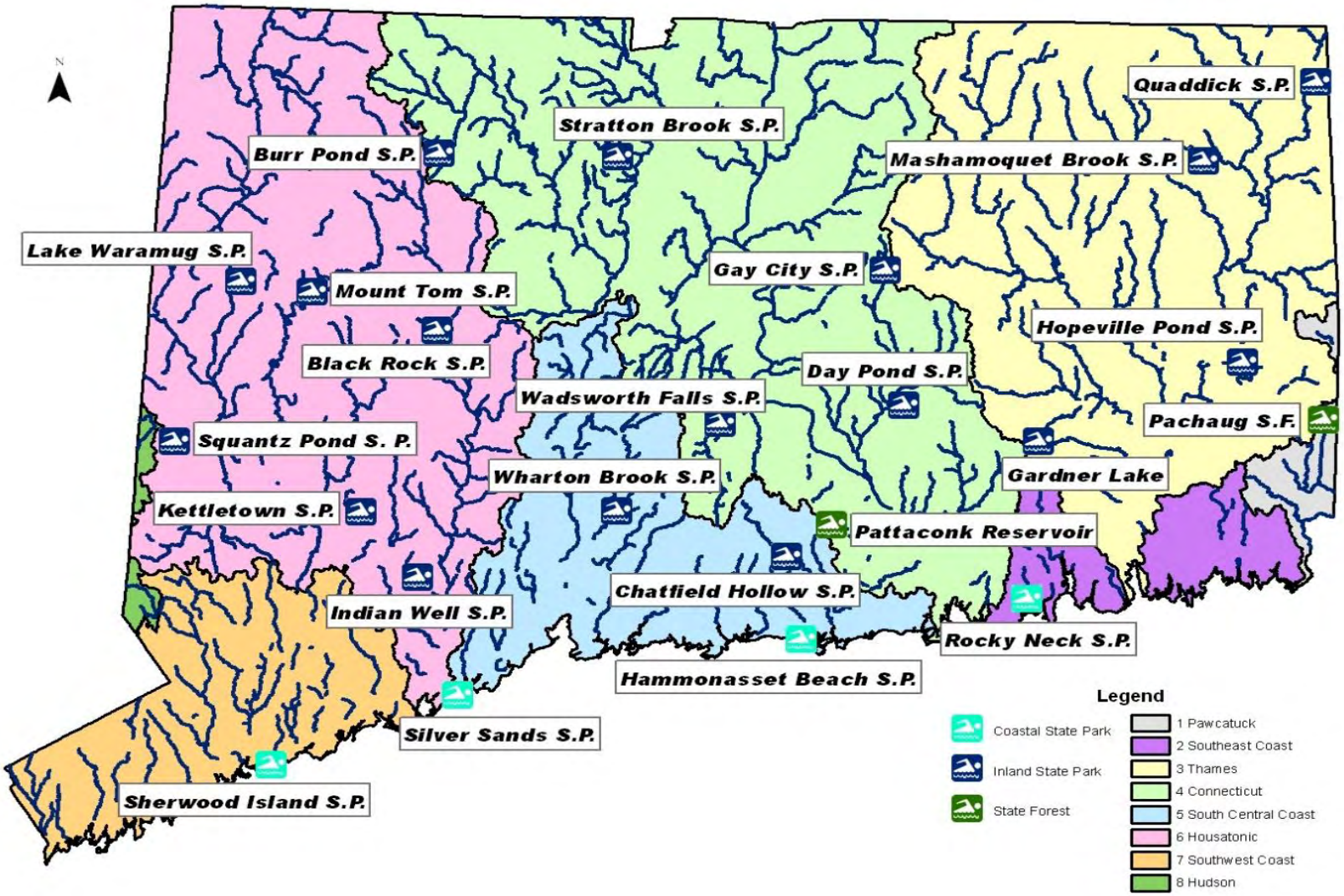


Figure 36. Twenty three state-owned beaches are located throughout the state to provide recreational opportunities to citizens from Memorial Day to Labor Day.

Water quality at state bathing beaches tends to be very good. During the 2006-2010 time frame seven of the State beaches were not closed for swimming at all. These beaches were: Gardner Lake, Hammonasset, Lake Waramaug, Mt. Tom, Pachaug State Forest, Pattaconk Reservoir, and Stratton Brook. Two beach areas were closed substantially longer than any others and greater than 10 % of the bathing days. They were Gay City and Wharton Brook State Parks (Figure 37 and Table 16).

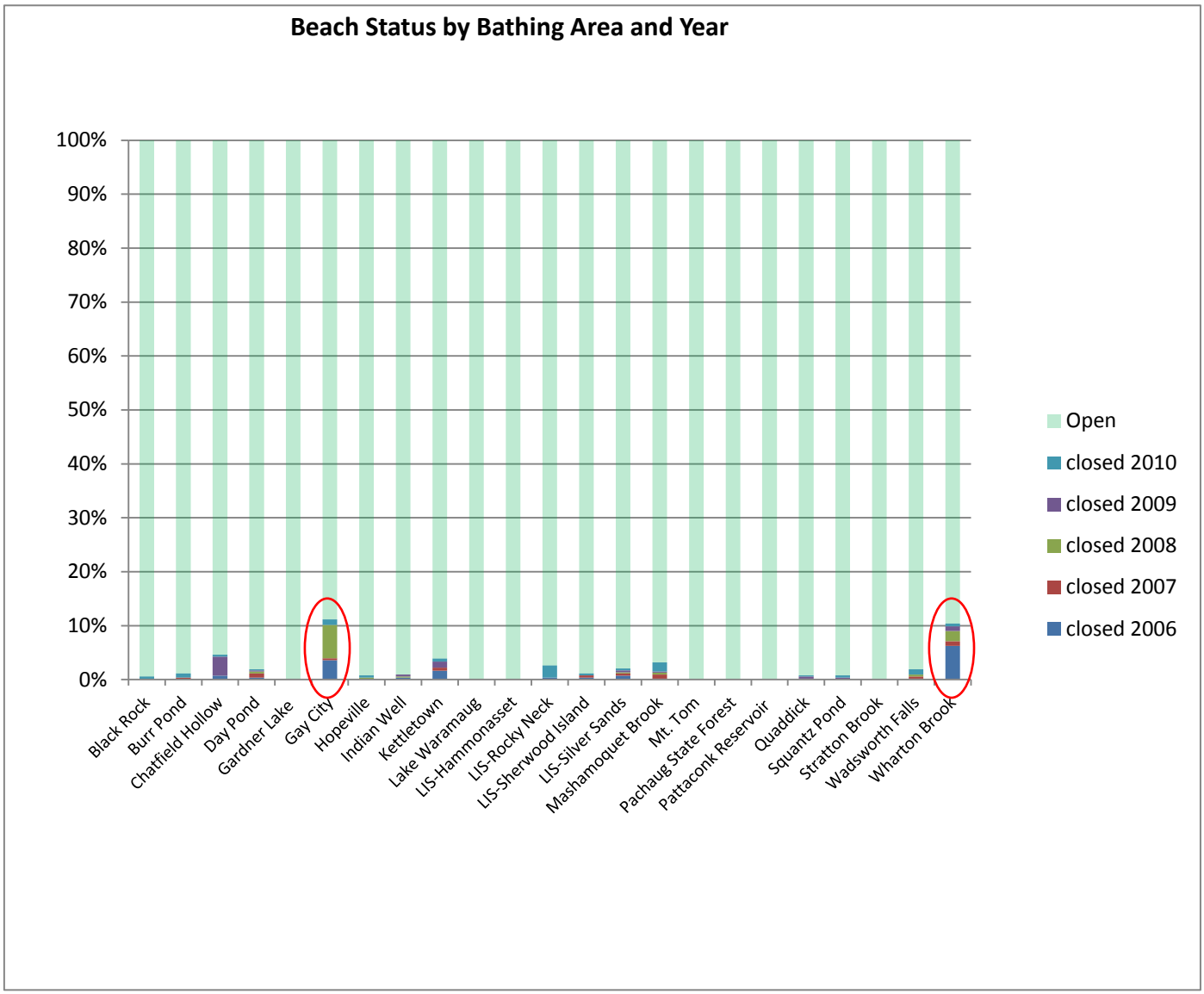


Figure 37. The percentage of time each state bathing area was open/closed by year and property. Overall state bathing areas were only closed 2.2% of the total days during 2006-2010. The red ovals indicate the 2 parks with the highest percentage of days closed between 2006-2010.

Table 16. Open/Closed summary statistics for state bathing beach areas from seasons 2006-2010.

5 Year Beach Closure Summary
Days Closed & Percent of Season Closed 2006-2010

State Bathing Area	2006		2007		2008		2009		2010			Total	
	Days	%	Days	%	Days	%	Days	%	Days	%		Days	%
Bathing Season	102		102		102		109		102			517	
Black Rock	0	0.0	0	0.0	0	0.0	0	0.0	3	2.9	=	3	0.6
Burr Pond	0	0.0	2	2.0	0	0.0	0	0.0	4	3.9	=	6	1.2
Chatfield Hollow	4	3.9	0	0.0	0	0.0	19	17.4	2	2.0	=	25	4.8
Day Pond	2	2.0	4	3.9	2	2.0	1	0.9	1	1.0	=	10	1.9
Gardner Lake	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	=	0	0.0
Gay City	21	20.6	2	2.0	36	35.3	0	0.0	6	5.9	=	65	12.6
Hammonasset Beach	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	=	0	0.0
Hopeville	0	0.0	0	0.0	2	2.0	0	0.0	2	2.0	=	4	0.8
Indian Well	2	2.0	0	0.0	1	1.0	2	1.8	0	0.0	=	5	1.0
Kettletown	9	8.8	3	2.9	0	0.0	6	5.5	3	2.9	=	21	4.1
Lake Waramaug	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	=	0	0.0
Mashamoquet Brook	1	1.0	4	3.9	2	2.0	1	0.9	9	8.8	=	17	3.3
Mt. Tom	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	=	0	0.0
Pachaug State Forest	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	=	0	0.0
Pattaconk Reservoir	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	=	0	0.0
Quaddick	0	0.0	1	1.0	0	0.0	2	1.8	1	1.0	=	4	0.8
Rocky Neck * +	2	2.0	0	0.0	0	0.0	0	0.0	12	11.8	=	14	2.7
Sherwood Island	2	2.0	2	2.0	0	0.0	0	0.0	2	2.0	=	6	1.2
Silver Sands	4	3.9	2	2.0	1	1.0	2	1.8	2	2.0	=	11	2.1
Squantz Pond	0	0.0	0	0.0	0	0.0	2	1.8	2	2.0	=	4	0.8
Stratton Brook	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	=	0	0.0
Wadsworth Falls	1	1.0	2	2.0	2	2.0	0	0.0	5	4.9	=	10	1.9
Wharton Brook	36	35.3	5	4.9	11	10.8	5	4.6	3	2.9	=	60	11.6
TOTAL =	84	3.6	27	1.2	57	2.4	40	1.6	57	2.4	=	265	2.2

* - east beach area closed for season (2006-2009) based on potenial high bacteria
\+ - 10 of 12 days closed in 2010 for east beach area only

Indicator bacteria counts are not necessarily linked to the presence of human fecal material. Several other sources that are suspected in playing a major role in elevated values are, storm water runoff, waterfowl presence on the beach or rafting in the bathing area, and pet waste. The potential for a bacterial exceedance seems to be associated with rainfall. Bathing areas had different number of days closed depending upon the year and the beach. For example all of the days closed for Black Rock Park (100%) were during 2010, whereas at Day Pond, days closed were roughly equivalent for 2006, 2007, 2008, 2009, and 2010 (Figure 38).

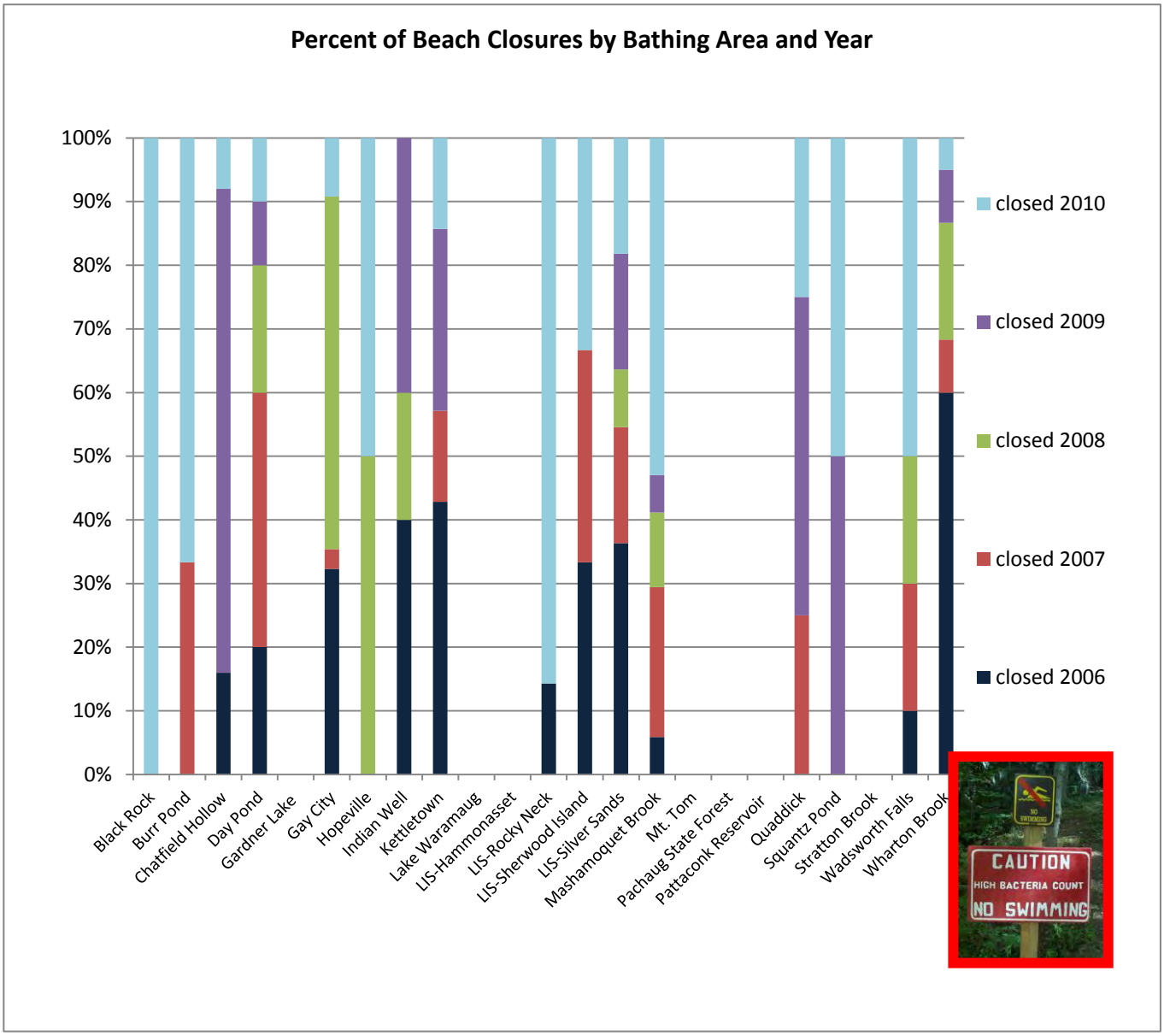


Figure 38. State bathing areas and the percentage of days closed between 2006-2010. No bar indicates that the bathing area was never closed during this time frame. Closures do not appear to follow any sort of pattern by year. For example in 2010 Black Rock had 100% of its closure days while Wharton Brook only had about 5% of its closure days.

Lakes

Overview: In Connecticut, there are a total of 2,267 lakes and ponds that are greater than 10 acres in size (Figure 39). Historically, Connecticut DEEP has assessed 105 - 115 significant lakes statewide for CWA 305(b) reporting. Significance was based on a lake having state or federal public access, or providing unique or otherwise important habitats. In incorporating previously listed 303(d) waters into the 305(b) assessment process in 2002, a number of lakes and ponds which are not considered significant, but are believed to have impairments, were added to the lake assessment list.

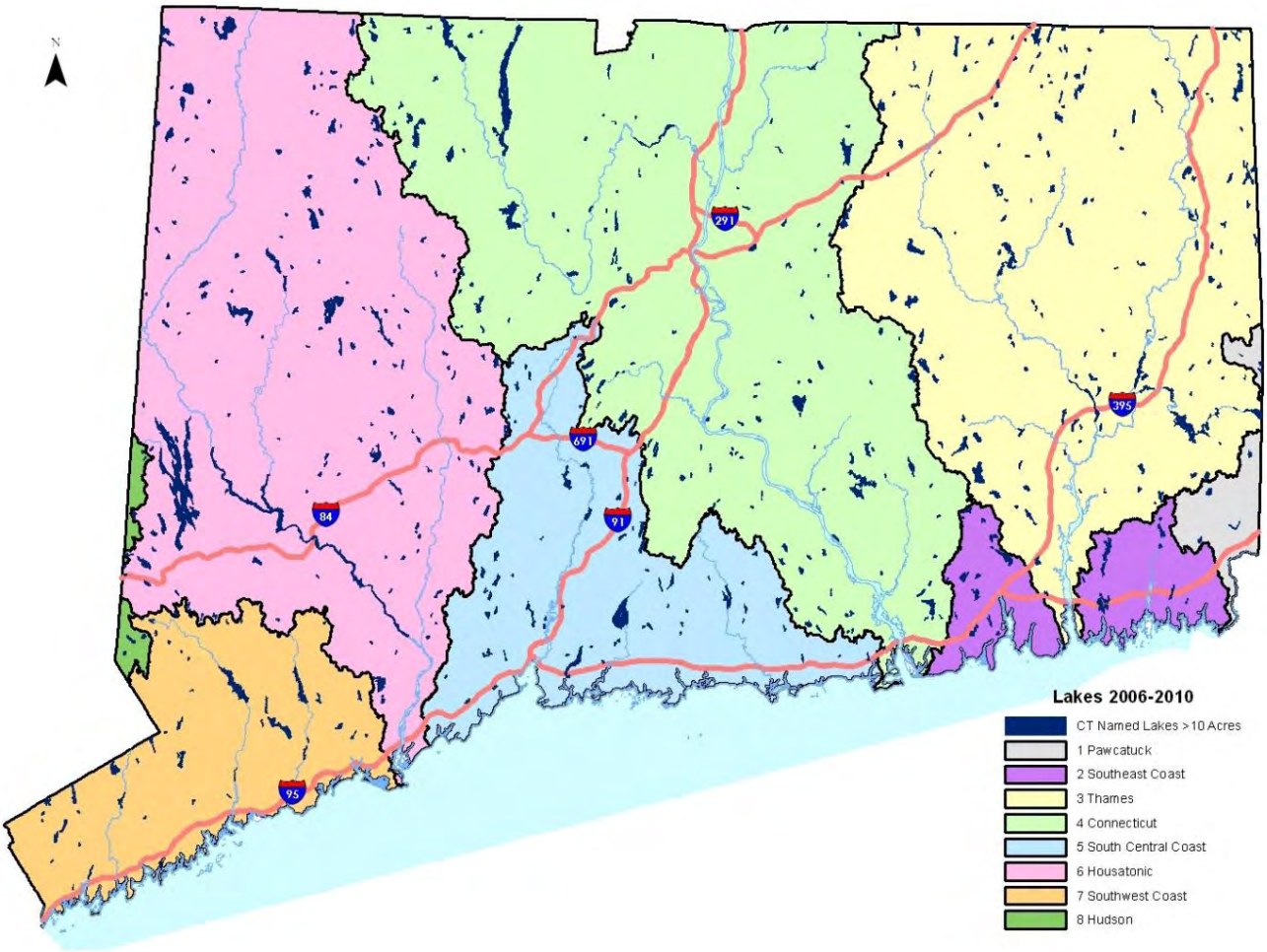


Figure 39. Lakes greater than 10 acres in Connecticut.

In DEEP's Ambient Monitoring Strategic Monitoring Plan, 2005, a number of lake studies were identified that were to be undertaken over a five period. The objectives of the studies were to determine the trophic conditions of the State's inland lakes, identify waters that are of high quality, identify those waters not meeting the State's water quality standards, determine if water quality is changing over time, identify emerging issues/problems, and to support DEEP lake watershed management programs.

Resulting data will be incorporated into lake assessments for 305(b) reporting as appropriate. Following completion of this project, DEEP will evaluate the utility of this type of monitoring in providing assessment information and whether it is feasible to continue.

In support of the Strategic Monitoring Plan, DEEP secured federal funding to conduct three lakes monitoring projects for the time period 2006 through 2010 (Figure 44 and Table 17). The three lake monitoring projects included the following:

Project 1. Connecticut Probabilistic Lake Monitoring (CT PROB), 2005 – 2007

The purpose of the monitoring project was to determine the lake trophic conditions throughout Connecticut and to help with CWA Sec 314 and 305 (b) reporting requirements. The study was conducted by Dr. Peter Siver of Connecticut College in New London.

Project 2. New England Lakes and Ponds Project (NELP), 2006 – 2009

The purpose of this monitoring project was to determine the ecological health and integrity at the national level and the regional level, respectively.

Results are pending for the Connecticut Probabilistic Lake Monitoring, 2005 – 2007 Project; a draft Report is currently under review by the Connecticut Department of Energy and Environmental Protection. Results from the National Lake Project (NLP) 2007 and New England Lakes and Pond Project (NELP) 2006-2009 can be found online at the following websites: www.epa.gov/owow/lakessurvey and www.epa.gov/ne/lab/nelp .

Project 3. National Lakes Assessment (NLA) 2007

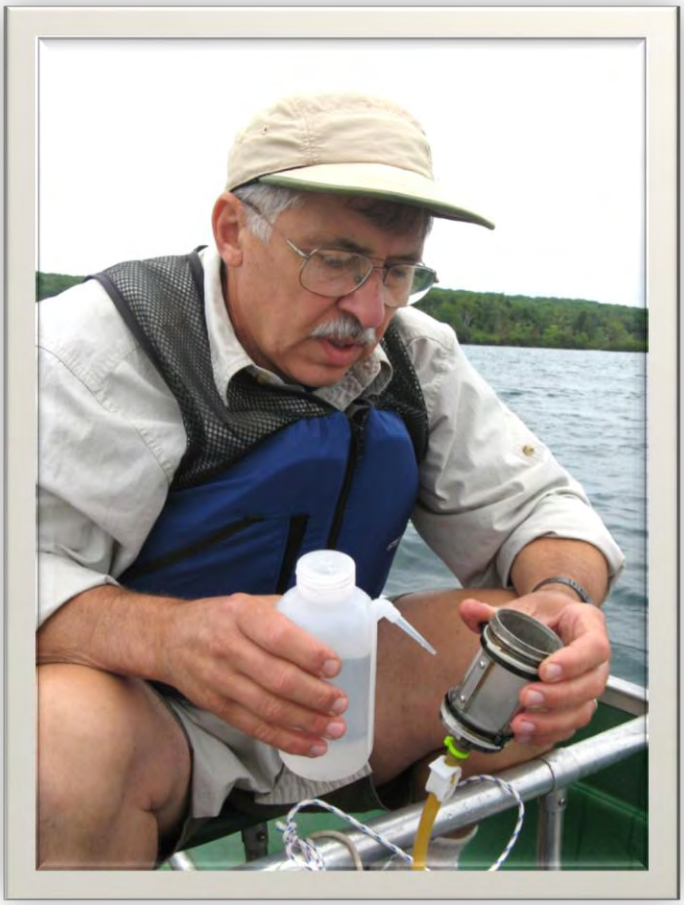
Overview: During the summer of 2007 DEEP participated in an US EPA sponsored project called the National Lakes Assessment (NLA). This project was based on a probabilistic sampling design that randomly selected 909 waterbodies that were at least 1 meter deep and 10 acres in size from across the lower 48 States. The project had several goals including:

- To assess the condition of U.S. lakes by determining what percentage of the nations lakes are in good, fair, and poor condition based on trophic, ecological, and recreational indicators.
- Determine the importance of key stressors such as nutrients and pathogens in determining the health and recreational value of the nation's lakes.
- To establish a baseline for future monitoring of lakes

- To assess trends in lake status in the past three decades.
- To help build state and tribal capacity for monitoring and assessment and promote collaboration across jurisdictional boundaries in the assessment of water quality.

What was done: Here in Connecticut fourteen lakes were sampled for a variety of limnological, biological, and physical habitat parameters. The waterbodies included Beardsley Pond, Bissonnette Pond, Groton Reservoir, Knowlton Pond, Lake Kenosia, Lake Waramaug, Lake Zoar, Morris Reservoir, Pachaug Pond, Riga Lake, Roseland Lake, Union Pond, West Hill Pond, and Wononpakook Lake.

Results: In general, the range of indicators in Connecticut's Trophic Category System for the 14 lakes in Connecticut based on, total nitrogen (Figures 40a-b), total phosphorus (Figures 41a-b), chlorophyll a (Figures 42a-b), and Secchi depth (Figure 43a-b) fell in between what was measured in the New England States (n=69) and those lake sampled throughout the Nation (n= 1,028). These evaluations are based on a single trip following standard sampling protocols for the NLA study and are not conclusive assessments of trophic status. Rather they are presented to show how Connecticut's lakes sampled in the NLA compared to lakes regionally and across the United States.



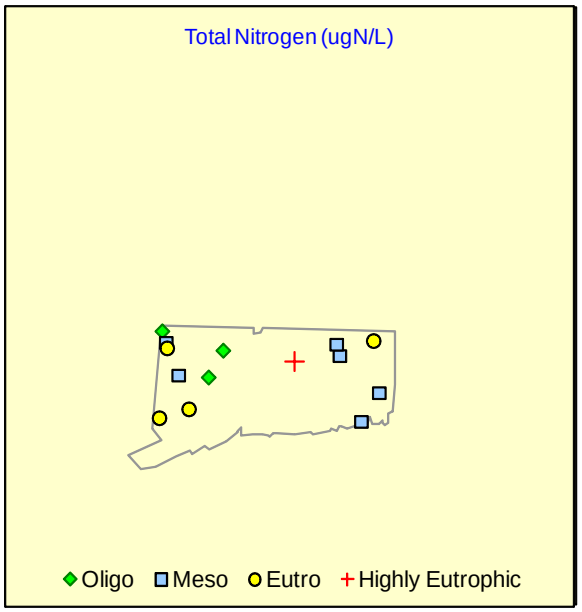


Figure 40a. Map of total nitrogen ranges for 14 lakes in Connecticut that were surveyed in 2007 for the National Lakes Assessment. Concentration ranges are based on Connecticut's Trophic Category System.

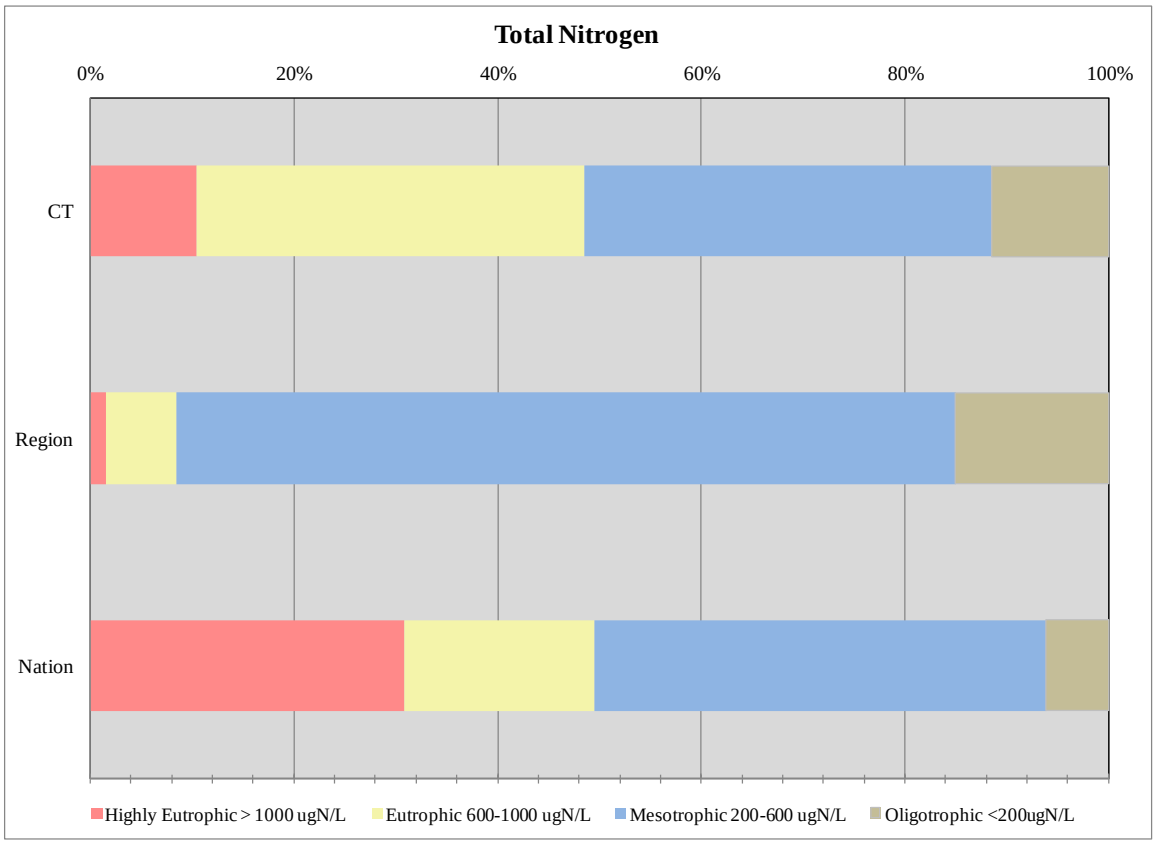


Figure 40b. Percentage of lakes from the 2007 National Lakes Assessment in Connecticut (CT; n=14), New England Region (Region; n=69), and nationally (Nation; n=1,028) that were in the eutrophic, eutrophic, mesotrophic, and oligotrophic range for total nitrogen based on Connecticut's Trophic Category System.

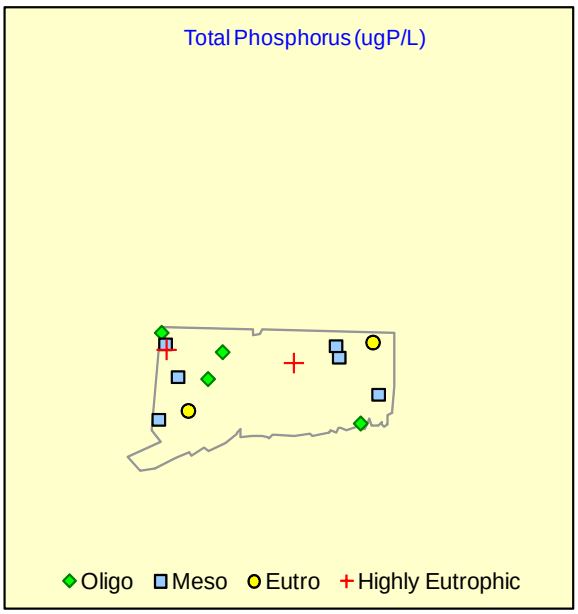


Figure 41a. Map of total phosphorus ranges for 14 lakes in Connecticut that were surveyed in 2007 for the National Lakes Assessment. Concentration ranges are based on Connecticut's Trophic Category System.

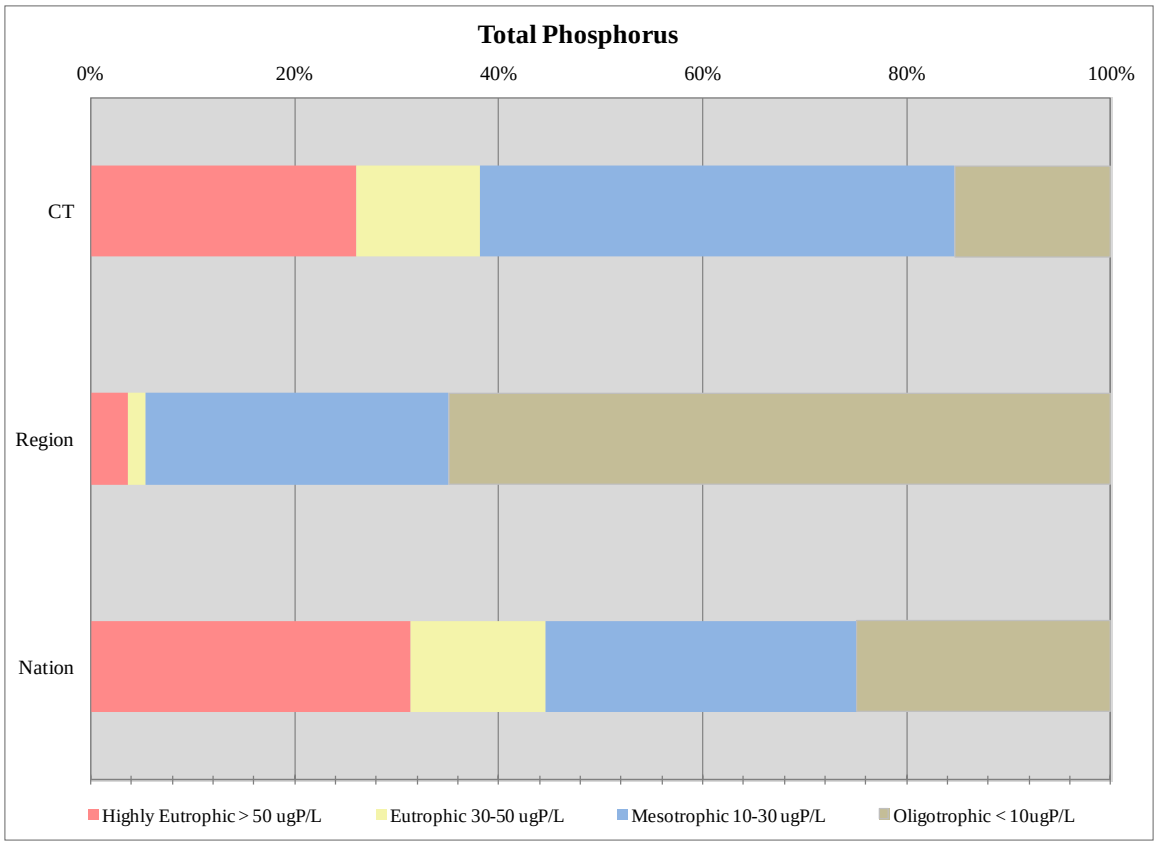


Figure 41b. Percentage of lakes from the 2007 National Lakes Assessment in Connecticut (CT; n=14), New England Region (Region; n=69), and nationally (Nation; n=1,028) that were in the eutrophic, eutrophic, mesotrophic, and oligotrophic range for total phosphorus based on Connecticut's Trophic Category System.

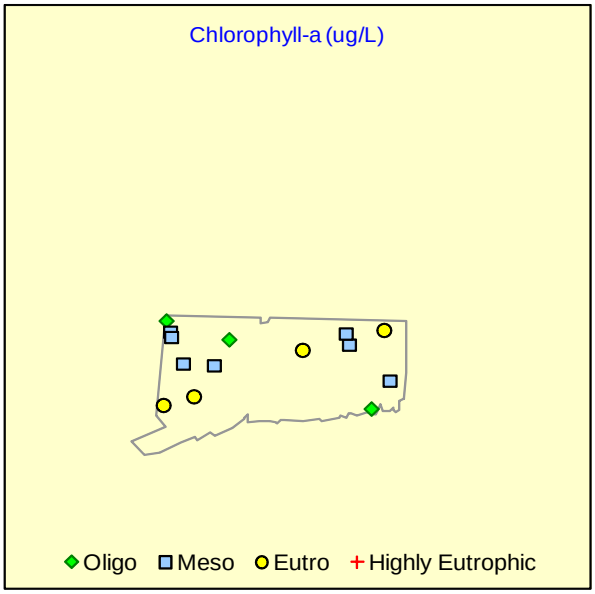


Figure 42a. Map of chlorophyll a ranges for 14 lakes in Connecticut that were surveyed in 2007 for the National Lakes Assessment. Concentration ranges are based on Connecticut's Trophic Category System.

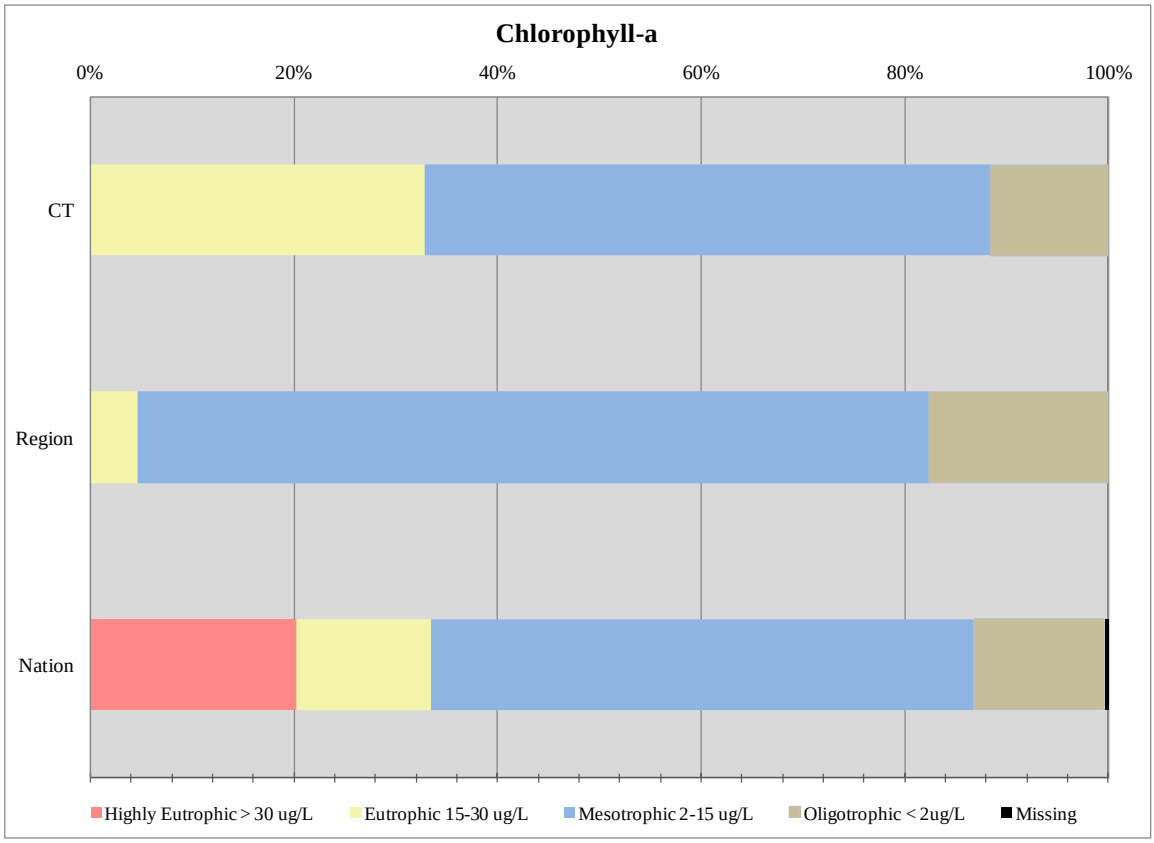


Figure 42b. Percentage of lakes from the 2007 National Lakes Assessment in Connecticut (CT; n=14), New England Region (Region; n=69), and nationally (Nation; n=1,028) that were in the eutrophic, eutrophic, mesotrophic, and oligotrophic range for chlorophyll-a based on Connecticut's Trophic Category System.

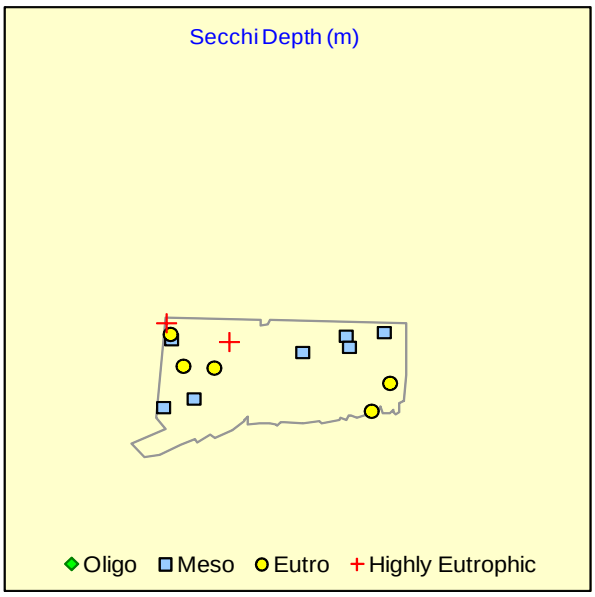


Figure 43a. Map of Secchi depth ranges for 14 lakes in Connecticut that were surveyed in 2007 for the National Lakes Assessment. Concentration ranges are based on Connecticut's Trophic Category System.

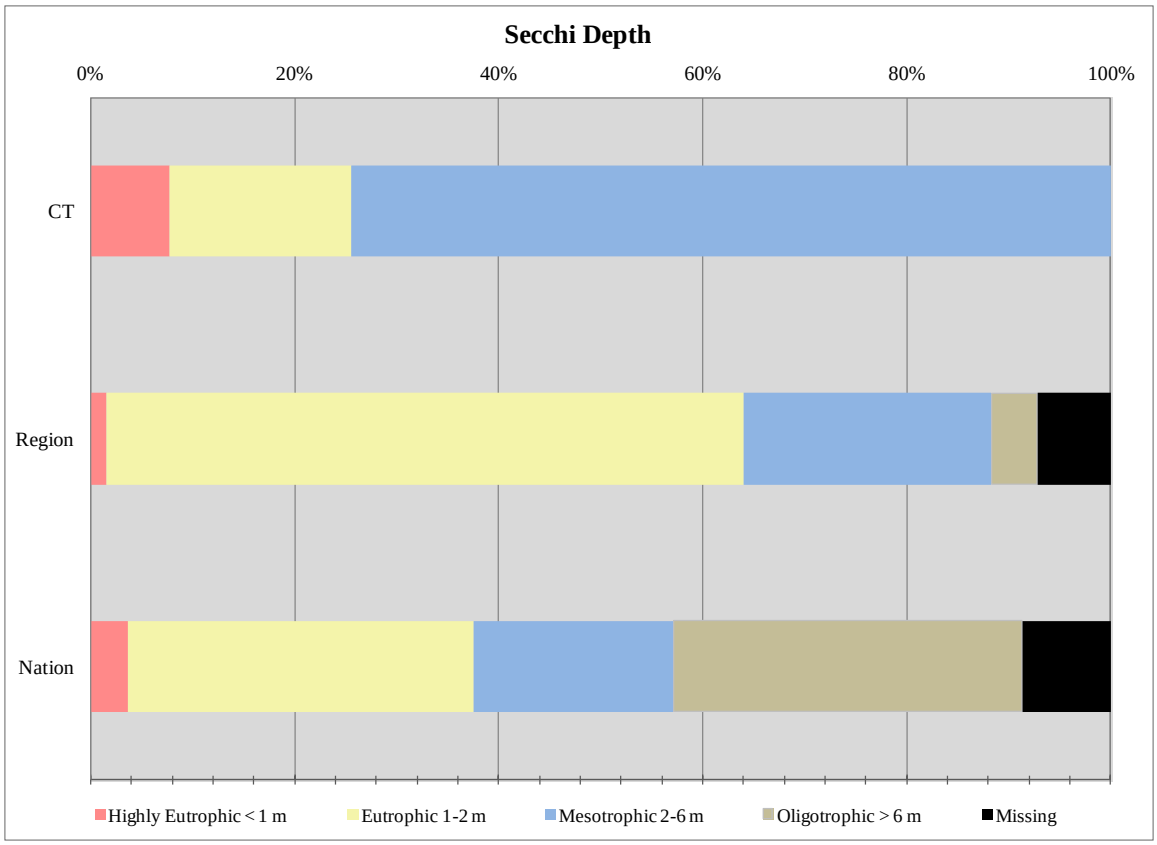


Figure 43b. Percentage of lakes from the 2007 National Lakes Assessment in Connecticut (CT; n=14), New EnglandRegion (Region; n=69), and nationally (Nation; n=1,028) that were in the eutrophic, eutrophic, mesotrophic, and oligotrophic range for Secchi depth based on Connecticut's Trophic Category System.

Figure 44. Location of the lakes sampled between 2006-2010 for three major projects, National Lakes Assessment NLA), New England Lake and Ponds (NELP), and Connecticut Probabilistic Monitoring (CT PROB). The number in the white circle corresponds to the map id in Table 17.

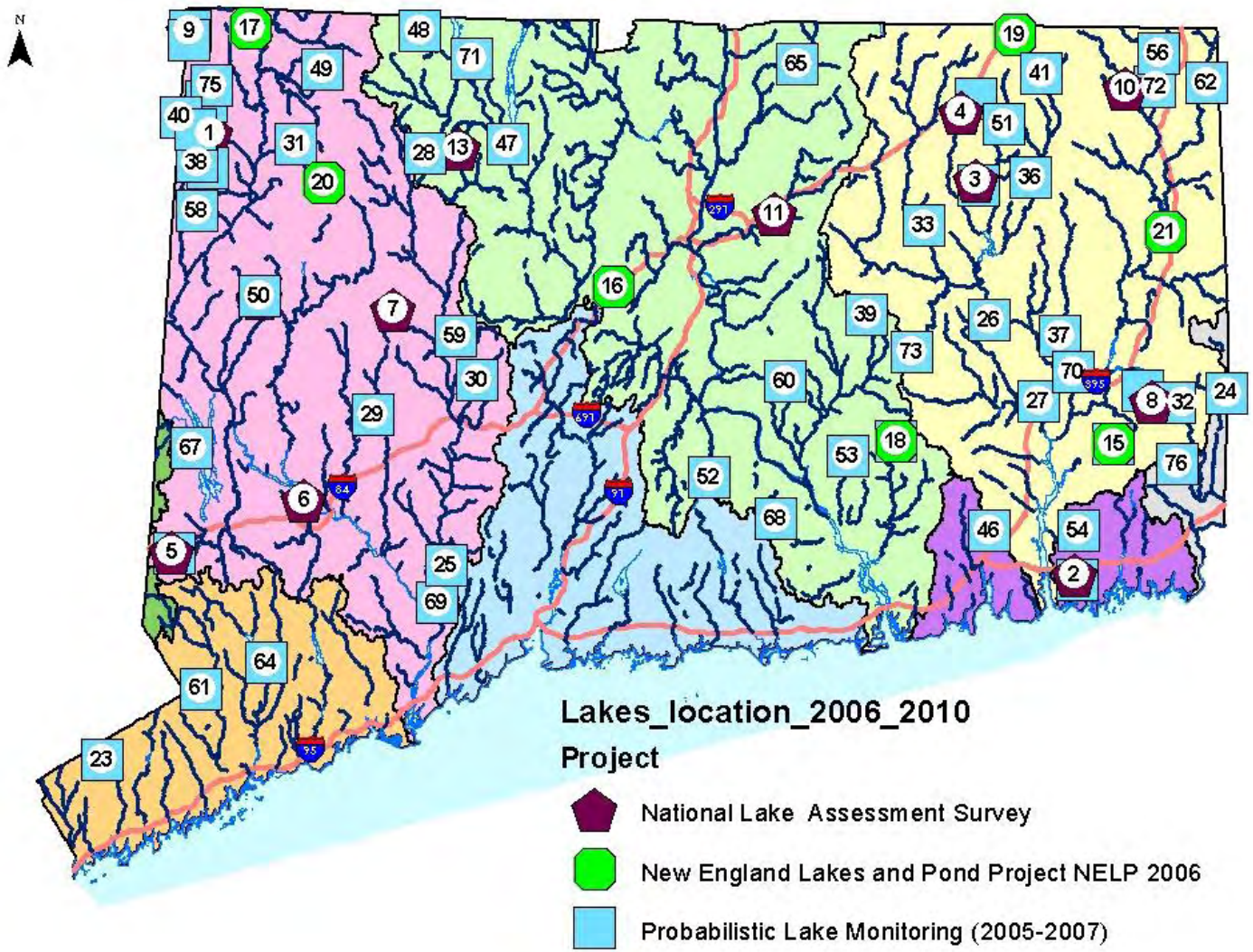


Table 17. Name and project for each of the lakes sampled between 2006-2010 for three major projects, National Lakes Assessment (NLA), New England Lakes and Ponds Project (NELP), and Connecticut Probabilistic Monitoring (CT PROB).

Map ID	Project	Lake Name	Map ID	Project	Lake Name
1	NLA	Beardsley Pond	40	CT PROB	Indian Lake
2	NLA	Groton Reservoir	41	CT PROB	Keach Pond
3	NLA	Knowlton Pond	42	CT PROB	Knowlton Pond
4	NLA	Lake Bissonnette	43	CT PROB	Lake Chaffee
5	NLA	Lake Kenosia	44	CT PROB	Lake Hayward
6	NLA	Lake Zoar	45	CT PROB	Lake Kenosia
7	NLA	Morris Reservoir	46	CT PROB	Lake Kononmac
8	NLA	Pachaug Pond	47	CT PROB	Lake McDonough (Compensating Reservoir)
9	NLA	Riga Lake	48	CT PROB	Lake Triangle
10	NLA	Roseland Lake	49	CT PROB	Lake Wangum
11	NLA	Union Pond	50	CT PROB	Lake Waramaug
12	NLA	Waramaug, Lake	51	CT PROB	Lake Winchester
13	NLA	West Hill Pond	52	CT PROB	Millers Pond
14	NLA	Wonoonpakook Lake	53	CT PROB	Moodus Reservoir
15	NELP	Amos Lake	54	CT PROB	Morgan Pond
16	NELP	Batterson Park Pond	55	CT PROB	Mudge Pond
17	NELP	East Twin Lake	56	CT PROB	North Grosvenordale
18	NELP	Lake Hayward	57	CT PROB	Pachaug Pond
19	NELP	Mashapaug Lake	58	CT PROB	Peck Pond
20	NELP	Tyler Lake	59	CT PROB	Plymouth Lake
21	NELP	Wauregan(Quinebuag Pond)	60	CT PROB	Pocotopaug Lake
22	CT PROB	Amos Lake	61	CT PROB	Popes Pond
23	CT PROB	Bargh Reservoir	62	CT PROB	Quaddick Reservoir
24	CT PROB	Beach Pond	63	CT PROB	Riga Lake

25	CT PROB	Beaver Lake	64	CT PROB	Saugatuck Reservoir
26	CT PROB	Big Pond	65	CT PROB	Somersville Pond
27	CT PROB	Bog Meadow Reservoir	66	CT PROB	South Pond
28	CT PROB	Burr Pond	67	CT PROB	Squantz Pond
29	CT PROB	Cat Swamp Pond	68	CT PROB	Turkey Hill Reservoir
30	CT PROB	Chestnut Hill Reservoir	69	CT PROB	Upper Derby Hill Reservoir
31	CT PROB	Cream Hill Lake	70	CT PROB	Versailles Pond
32	CT PROB	Doaneville Pond	71	CT PROB	West Branch Reservoir
33	CT PROB	Eagleville Pond	72	CT PROB	West Thompson Reservoir
34	CT PROB	Ford Pond	73	CT PROB	Williams Pond
35	CT PROB	Groton (Poquonnock) Reservoir	74	CT PROB	Wononpakook Lake
36	CT PROB	Halls Pond	75	CT PROB	Wonoscopomuc Lake
37	CT PROB	Hanover Reservoir	76	CT PROB	Wyassup Lake
38	CT PROB	Hatch Pond			
39	CT PROB	Holbrook Pond			

VI. Special Projects

Impervious Cover Studies

Impervious cover is any land cover that disrupts the natural flow of water into the ground and instead channels or directs runoff directly into a waterbody. A major source of impervious cover is development of the landscape, the building of parking lots, large roof buildings, and roads. In general as impervious surface increases on the landscape the quality of the biological communities decreases (Figure 45). WPLR conducted two studies to evaluate fish and macroinvertebrate communities; one examining **moderately developed** (6-14 % IC) watersheds and one examining **least disturbed (**less than 4% IC and other criteria**)** [Bellucci and others, 2011]. Funding for these studies was provided, in part, by the EPA as a 104(b) (3) program grant. More detail on this work can be found on the DEEP Website (http://www.ct.gov/dep/imperviouscoverstudies).

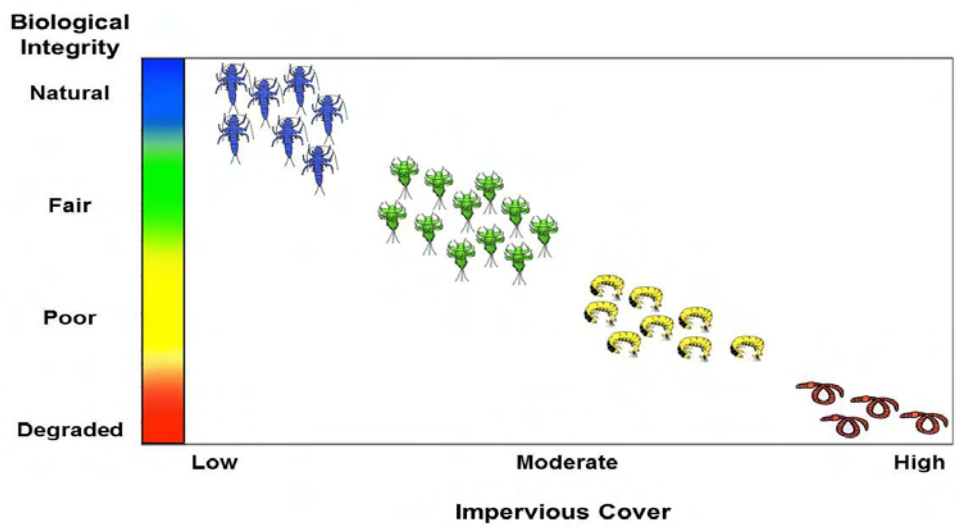
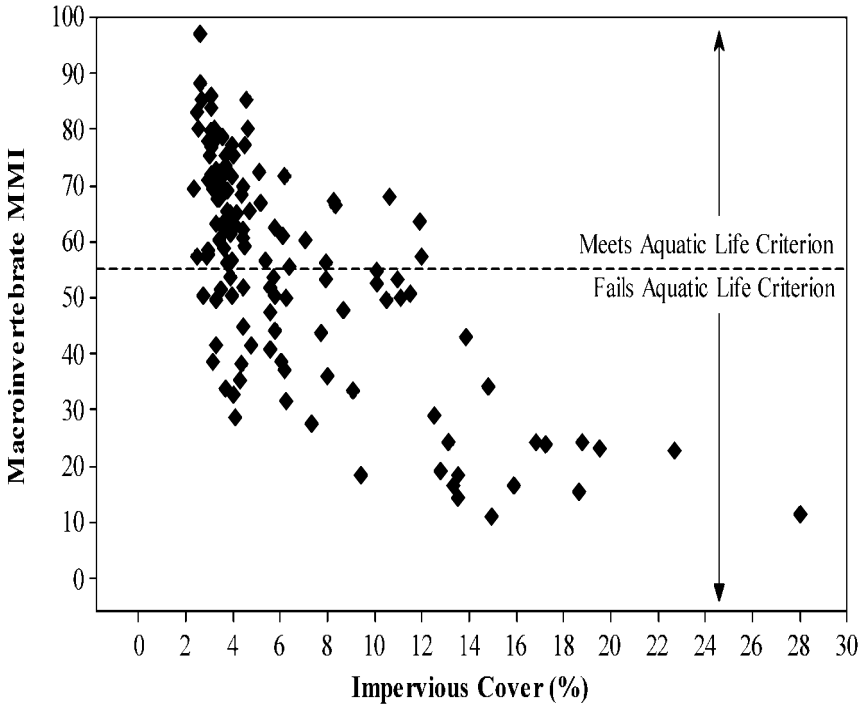


Figure 45. General relationship between stream health as measured by biological integrity (usually fish or macroinvertebrates) and relationship with impervious land cover. Streams that are natural have high biological integrity and are generally found in places with low impervious land cover. In contrast, streams that are degraded are generally found in places with high impervious cover.

In summary these studies have shown that a 2% increase in impervious land cover can result in about a 6 point decrease in a stream health metric. Meaning as increasing urban land use has a measureable decrease on stream health. They have also shown at 12% impervious cover no macroinvertebrate samples meet state water quality standards (Figure 46) and no sites had wild brook trout present (Figure 47)

Figure 46. Scatter plot of percent total impervious cover and macroinvertebrate multi-metric index (MMI) for 125 stream monitoring locations in Connecticut. Sites that plot above the horizontal line meet Connecticut's water quality criterion to support aquatic life. Sites that plot below the horizontal line do not meet Connecticut's water quality criterion to support aquatic life. No sites with greater than 12% impervious cover have been shown to meet aquatic life goals.



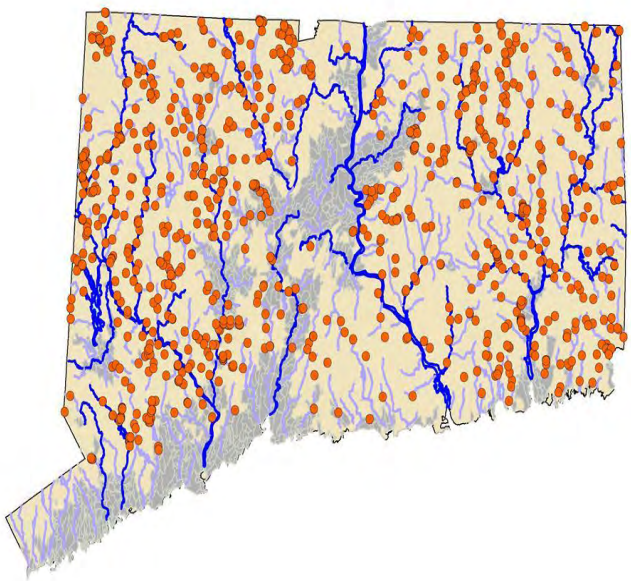
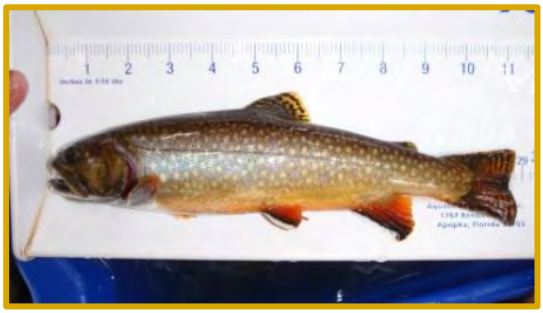
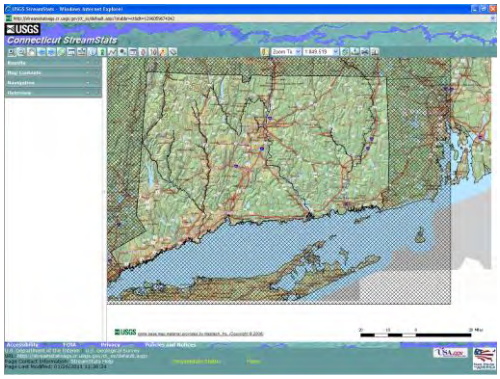


Figure 47. Wild brook trout and impervious cover in Connecticut. These data are from 3,478 sampling locations from DEEP Fisheries 1988-2006. The orange circles are sites where at least 1 wild brook trout was sampled and represents approximately 33% of the sites (n=1,159). The grey shaded area is > 12% impervious cover.



StreamStats

StreamStats is a web-based Geographic Information System provided by the United States Geological Survey (USGS) that allows users to obtain streamflow statistics, drainage basin characteristics, and other stream-related information. These tools are helpful for water resources managers in areas such as protecting people and property from floods. For the Planning and Standards Division of the DEEP Bureau of Water Protection and Land Reuse, StreamStats can provide useful statistics for Total Maximum Daily Load (TMDL) analyses. With funding from the EPA's 104(b)(3) program grant DEEP contracted with USGS to develop low flow statistics such as the 7-day, 10-year low flow (7Q10) and low flow exceedances (e.g., 99th percentile flow) that are necessary to calculate TMDLs.



The completed report is published in 2010 is available on the USGS website at http://pubs.usgs.gov/sir/2010/5052/ .

Small Dam Study

The ecology of aquatic biota in rivers and streams downstream of dams is affected by multiple stressors. The DEEP's Stressor Identification Procedures are utilized to determine the most likely cause of aquatic life impairments for Total Maximum Daily Load (TMDL) development. Dams add complexity to this process because they modify streamflow; alter the quality and quantity of sediments, water temperature, food/nutrient dynamics, and physical habitat; and create physical barriers to movement. In 2008, DEEP began a study entitled *Multiple Stressor Effects of Dams on Aquatic Biota in Connecticut Streams* to improve the understanding of dam impacts on aquatic biota for stressor identification studies in waters with impaired aquatic life uses. Fourteen sites from two watersheds were selected for sampling. In 2009, sites were sampled for water temperature using *in situ* data loggers. Fish community sampling was conducted in summer of 2009. Benthic macroinvertebrate samples were collected in fall 2008 and 2009. A summary report titled *Effects of Small Dams on Aquatic Biota in Two Connecticut Streams* is available of DEEP website http://www.ct.gov/dep/cwp/view.asp?a=2719&q=487892&depNav_GID=1654

Characteristics of Cold Water Fish Habitat

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 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 (Figure 48). The purpose of this document is to present water temperature data collected at these locations so to better inform management decisions regarding cold water 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. A summary report titled *Temperature Characteristics of Cold Water Fish Habitat 2010* is available of DEEP website http://www.ct.gov/dep/cwp/view.asp?a=2719&q=487892&depNav_GID=1654

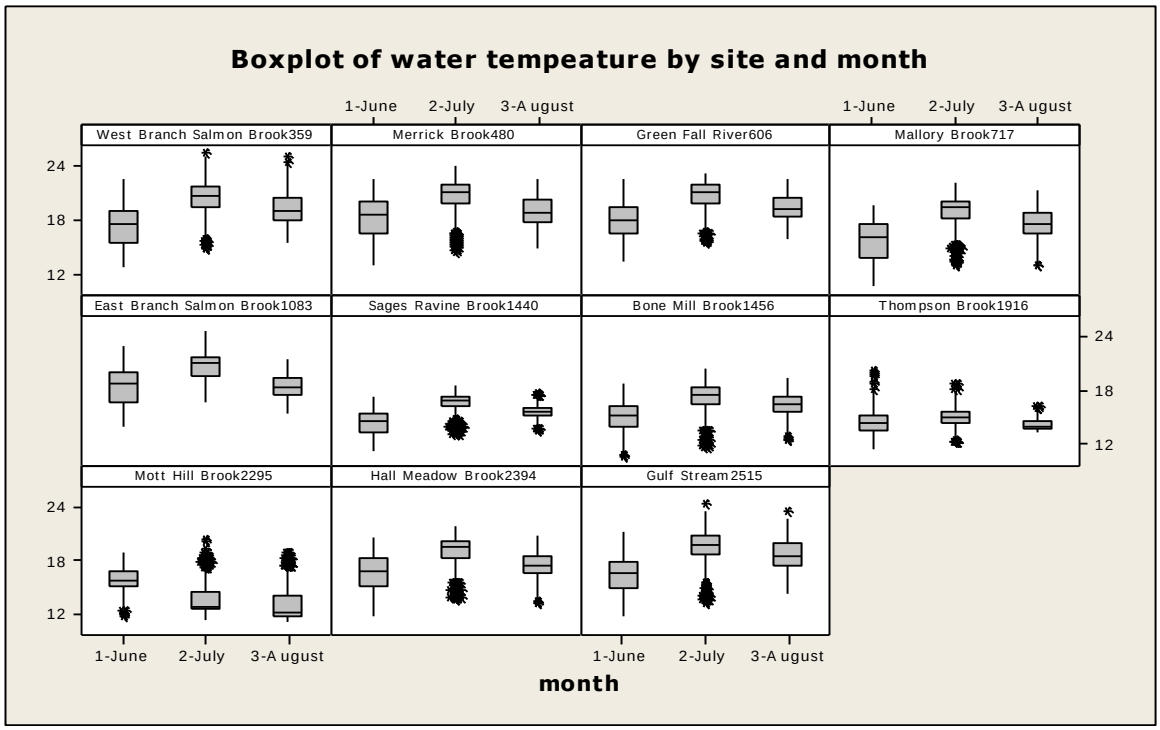


Figure 48. Distribution of water temperatures during summer 2010 as part of the cold water habitat characteristic project.

Biological Monitoring Method Development

Screening Organisms

Mayflies (Ephemeroptera)
Isonychia sp.
Drunella sp.*
Epeorus sp.*
Maccafertium vicarium *
Ephemerella sp. / Serratella sp.
Leucrocuta sp.*
Leptophlebiidae sp.
Stoneflies (Plecoptera)
Pteronarycidae sp.*
Peltoperlidae sp.
Perlidae sp.
Isoperla sp.*
Chloroperlidae sp,*
Leuctridae sp.
Caddisflies (Trichoptera)
Rhyacophilia sp.
Apatania sp.
Brachycentrus sp.
Psilotreta sp.
Helicopsyche borealis*
Diplectrona sp.
Microsema sp.
Lepidostoma sp.
Others
Hexatoma (Diptera)
Ancytarsus bicolor (Coleoptera)*
Stylogomphus albistylus (Odonata)
Psephenus sp./Ectopria sp. (Coleoptera)
Atherix Variegata (Diptera)

**= Elite taxa

Macroinvertebrate Field Screening Method: Traditional sampling of the macroinvertebrate community involves the collection and random sub-sampling of 200 organisms from approximately $2m^2$ of stream riffle habitat (Plafkin and others, 1989). The outcome of this type of sample is an enumeration of the species present. This method is relatively quick in the field but has a lengthy laboratory component for both sub-sampling and species identification. The generation of the species list and resulting MMI and BCG scores can be as much as six to eight months after field collection.

Beginning with the 2006 index period WPLR implemented a field-based method designed to provide one of three outcomes immediately in the field; the community clearly meets ALUS goals (pass), the community clearly fails ALUS goals (fail), or the community is on the boundary of meeting/failing ALUS goals (inconclusive) (Table 12). This type of sampling was implemented at probabilistic sites as a test because the answer needed for the probabilistic statewide assessment is pass or fail (Figure 48).

Table 12. The decision criteria for the macroinvertebrate screening method used at the 100 probabilistic sites sampled 2006-2010.

Screening Sample Outcome	Screening taxa
>= 6 Screening taxa	Pass
5 Screening taxa and 1 or more elite taxa	Pass
5 Screening taxa and 0 elite taxa	Inconclusive
3-4 Screening taxa	Inconclusive
0-2 Screening taxa no qualifier checks (High abundance of Hydropsychid caddis, high % non-insects, high % midges, very low sample abundance, or best professional judgment concern)	Inconclusive
0-2 Screening taxa with >= 1 qualifier check (High abundance of Hydropsychid caddis, high % non-insects, high % midges, very low sample abundance, or best professional judgment concern)	Fail
0-2 Screening taxa (Perlidae, Psephenus, or Isonyichia only)	Fail

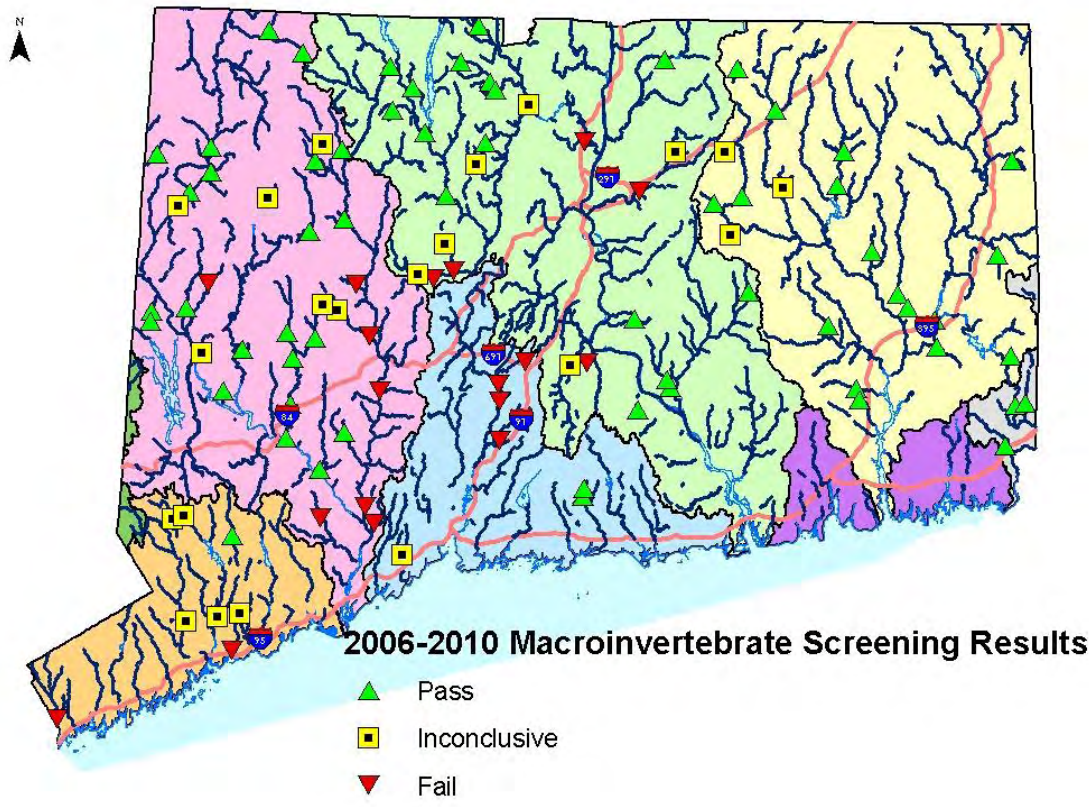


Figure 48. The screening sample results for the 100 samples collected at probabilistic sites from 2006-2010. There were 61 sites that passed, 21 sites were inconclusive, and 18 sites failed ALUS goals.

The method involves collecting organisms from approximately $1m^2$, searching for a select set of taxa, tallying the number and type of taxa present, and vouchering a representative specimen of each taxa. From the taxa present in the initial sample either the result is determined or a second $1m^2$ may be required. If the final outcome is inconclusive the entire sample, 2m2, is treated like a traditional sample being returned to WPLR laboratory for sub sampling and species identification.

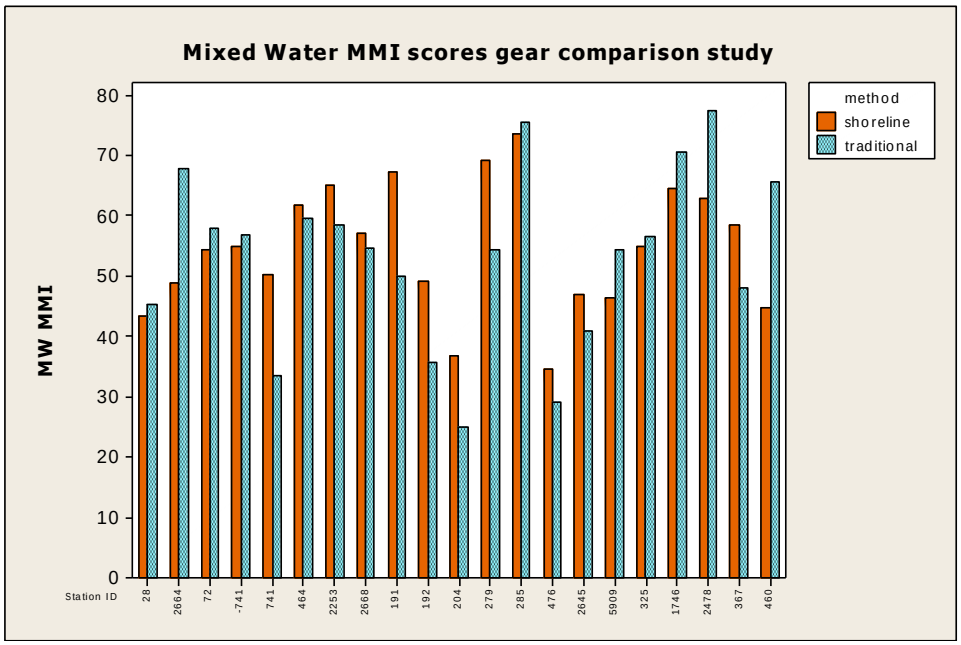
The benefit of this method over traditional sampling is the immediate turn around on results. This allows WPLR to sample many locations, obtain an answer, and bracket stream segments where invertebrate community changes. The downside is that neither an MMI nor BCG score can be calculated. For more information about this method please contact Guy.hoffman@ct.gov

Fish Community Large River Stream Margin Sampling Method:

WPLR routinely collects ambient fish community data in order to complement macroinvertebrate community data in support of CWALUS assessments. Since fish are highly mobile and can readily avoid capture, sampling effort including both specialized gear and additional personnel increases with increasing stream width. The purpose of this project was to evaluate an alternative shoreline sampling method against the traditional whole channel effort in large wadeable river segments.

Forty-seven fish community samples (21 each method) and 5 samples (stream margin only) were collected during the 2008-2010 summer low-flow index periods. These samples were collected from 20 stream segments covering 9 different waterbodies. The MWMMI score and review of select fish community structure indexes for each sample were used as the final endpoints for method similarity comparisons.

Comparison of the traditional and shoreline collection methods indicate comparable findings at the majority of locations. Both methods adequately capture the resident fish community structure, but differ slightly on the length-frequency distribution generated. The shoreline method tends to capture more individuals in the juvenile or young-of-year class while the traditional method tends to capture more adult individuals. The final report is available on the DEEP webpage at: http://www.ct.gov/dep/cwp/view.asp?a=2719&q=487892&depNav_GID=1654



The shoreline method is an adequate replacement for the traditional method when the intended use of fish community data is for CWA ALUS assessments. As the shoreline method is much less labor and resource intensive, implementation will enable WPLR to increase the number of paired fish and macroinvertebrate data from large wadeable stream segments. The traditional method can be implemented to provide a second opinion or when additional information to augment water quality management decisions, especially when the assessment is ambiguous.

Descriptions of the 2 fish community sampling methods that were compared in this study:

Shoreline method: A crew of 3-4 personnel uses a single backpack electrofishing unit to collect all fish within five (5) meters of each stream bank throughout the sample reach (yellow lines in right side photo).

Traditional method: Multiple crews of totaling 10-15 personnel use two (2) or more tote-barge electrofishing units simultaneously side-by-side (yellow lines in right side photo).

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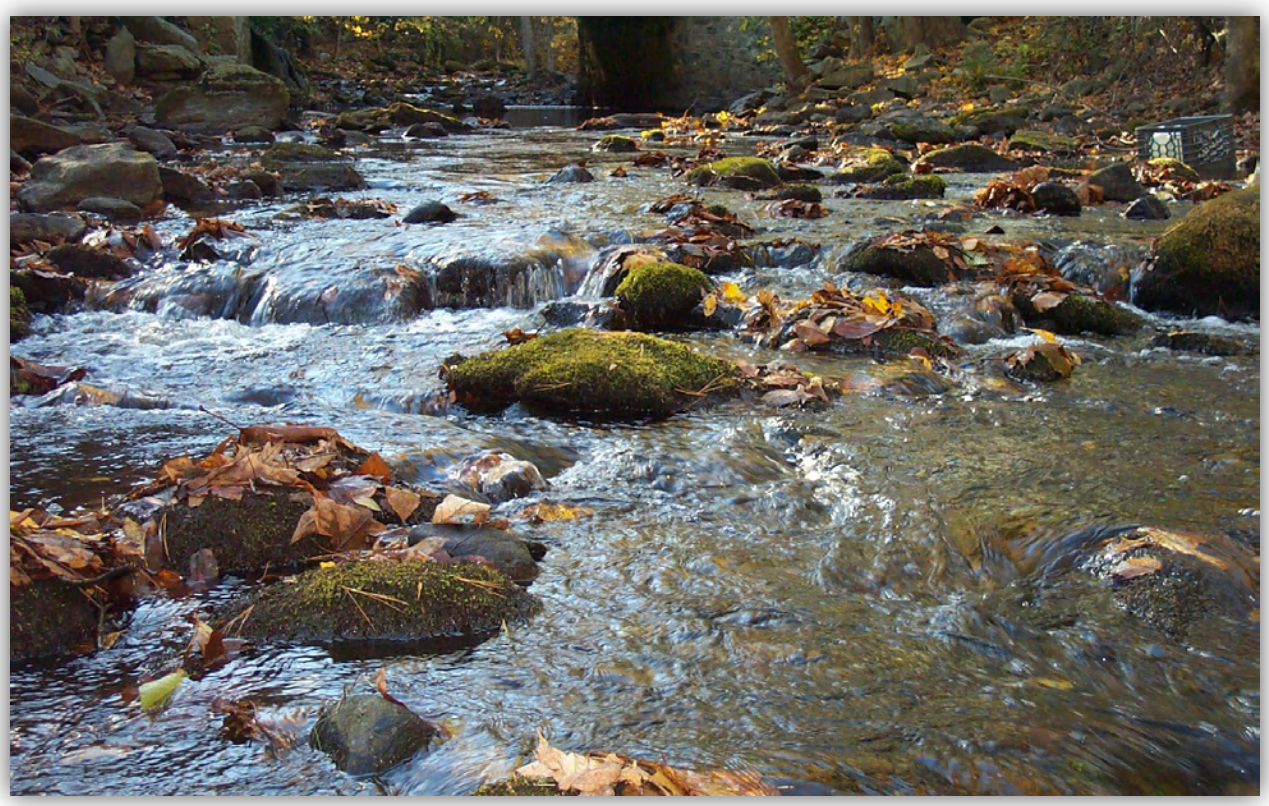
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