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Probability-based survey designs provide a scientifically rigorous way to **provide an estimate of the quality of all waters.**

The CT Monitoring and Assessment Program have conducted **three probability-based surveys from 2001 - 2015**.

Increases of Chloride and Calcium concentrations and **decreases of low-level phosphorus concentrations and mid-level macro-invertebrate metric index values** were observed.

These observations warrant further exploration to examine possible explanations of the changes that occurred over this 15 year period.

Exploratory Analysis of Three Periodic Probability-Based Surveys in Connecticut Wadeable Streams

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Overview

Probability-based survey designs provide a scientifically rigorous way to sample a subset of all waters and then provide an estimate of the quality of all waters along with a statement about the uncertainty surrounding that estimate. In a probability survey, a subset of waters is randomly selected. This ensures the "representativeness" or unbiased nature of the samples. The CT DEEP Monitoring and Assessment Program has conducted three periodic probability-based surveys between 2001 and 2015. These surveys targeted wadeable perennial streams within the geographic boundaries of Connecticut. Biological and chemical samples were collected as part of these surveys. We calculated population estimates for all available data and made note of areas for further exploration. Select results are presented.

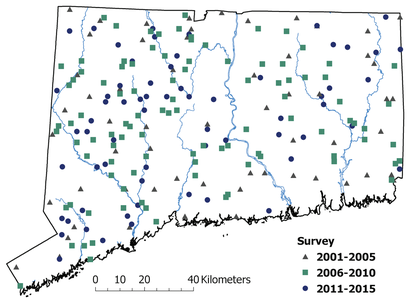
Study Background

Design Details

Target Population: All wadeable perennial streams within the geographic boundaries of Connecticut.

Timeframe: Three surveys were conducted within 5-year monitoring periods: 2001 – 2005, 2006 – 2010, 2011 – 2015

Sample Frame: 2001 – 2005 survey used US EPA's Reach File Version 3 (RF3) 1:100,000 scale with reaches coded as perennial. 2006 – 2010 and 2011 - 2015 surveys used the National Hydrography Dataset (NHD) Flowline 1:24,000 scale with reaches coded as perennial.



2001 – 2005 – Total stream length (km) = 9931*
2006 – 2010 – Total stream length (km) = 12509
2011 – 2015 – Total stream length (km) = 12509

*Total stream length is different from other surveys because a different GIS stream layer was used.

Survey Design: 2001 – 2005 used geographically stratified hex-design for a linear continuous network with probability based on stream length in hex and over-sample. Later surveys used Generalized Random Tessellation Stratified (GRTS) (Stevens and Olsen, 2004) for a linear continuous network with equal probability and over-sample.

Sampling Details

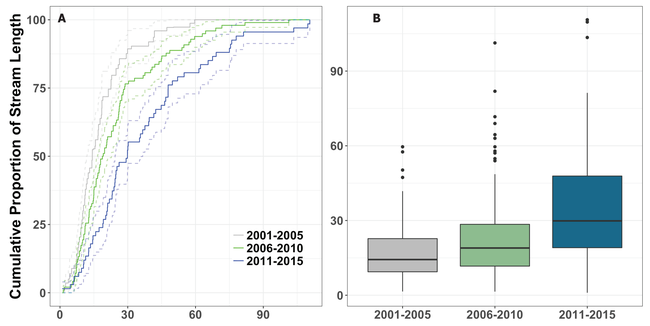
Survey	Site N	Chemical	Macro-Invertebrate	Fish	Diatoms	YSI	Continous Temperature
2001 - 2005	59	X	X	X	X	X	
2006 - 2010	100	X	X	X		X	
2011 - 2015	67	X	X	X	X	X	X

Analysis Details

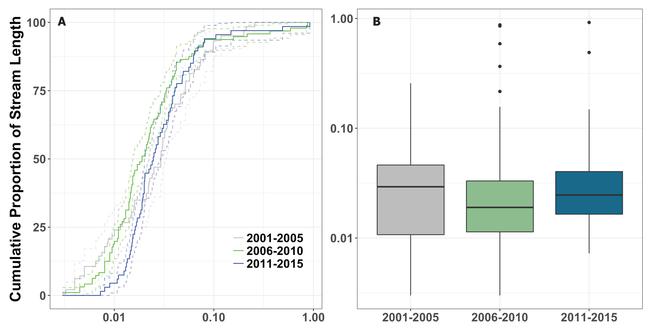
Description of Statistical Methods: Population estimates are based on samples from each stream and use weighted Horvitz-Thompson estimation. We used the local mean variance estimator to develop confidence intervals around the population estimates. Computations were conducted using the spsurvey package in R.

Select Chemical Results

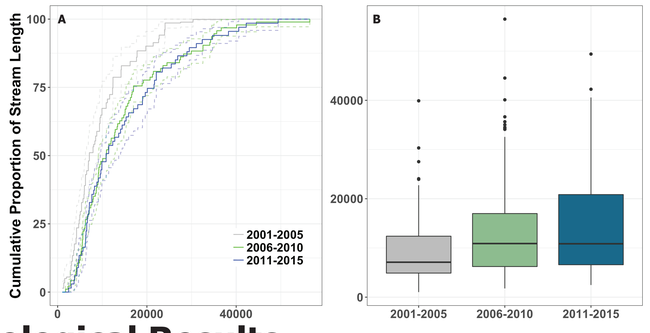
Chloride (CL) (mg/L)



Total Phosphorus (TP) (mg/L)



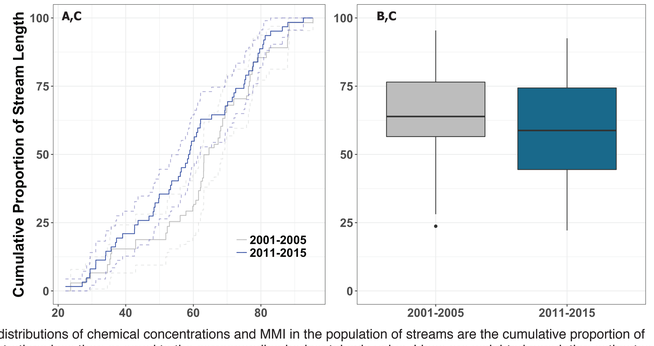
Calcium (CA) (µg/L)



Select Biological Results

Macro-Invertebrate Multi-Metric Index (MMI) Range (0 - 100)*

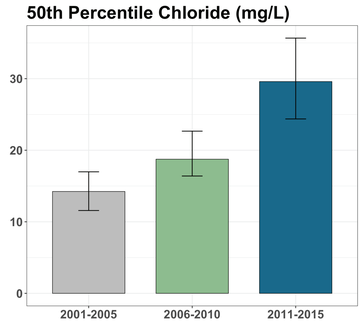
*Poor to Excellent Water Quality



A. Cumulative frequency distributions of chemical concentrations and MMI in the population of streams are the cumulative proportion of stream length with concentrations less than or equal to the corresponding horizontal axis value. Lines are weighted population estimates and 95% confidence intervals for total stream length in each survey.
B. Boxplots show distributions of chemical concentrations and MMI in the population of streams for each survey. The horizontal bars on each box plot correspond to the 25th, 50th and 75th percentiles of concentration values. The solid lines extend within 1.5 times the interquartile ranges (distance between the 25th and 75th percentiles). Data beyond the solid lines are plotted as points.
C. The macro-invertebrate MMI was not calculated for the 2006–2010 survey because a different sampling method was used during that time period that was not comparable to the other surveys.

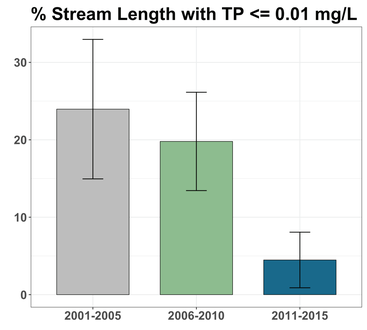
Areas for Further Exploration

50th Percentile Chloride (mg/L)



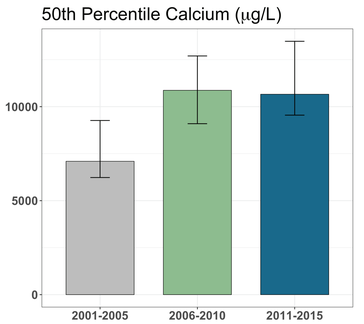
The median (50th percentile) CL value has doubled from the first to the third survey. It has increased from 14.2 to 18.8 to 29.6 mg/L from the 2001 – 2005 to the 2011 – 2015 survey.

% Stream Length with TP <= 0.01 mg/L



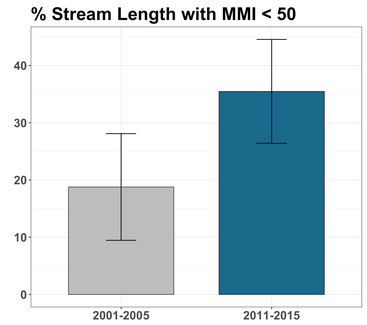
The percentage of stream length with TP <= 0.01 decreased from 24 to 19.9 to 4.5% between the 2001 – 2005 and the 2011 – 2015 survey. This is comparable to national surveys where the percentage of stream length with TP < 0.01 in the U.S. decreased from 24.5 to 10.4 to 1.6% from 2004 to 2009 to 2014 (Stoddard et al 2016).

50th Percentile Calcium (µg/L)



CA median (50th percentile) values increased by 35% between the first and second survey. CA median values were 7095, 10870 and 10661 µg/L for the 2001 - 2005, 2006 - 2010, and 2011 - 2015 surveys, respectively.

% Stream Length with MMI < 50



The percentage of stream length < a MMI value of 50 increased from the 2001- 2005 to the 2011-2015 survey. A MMI value of 50 is a mid-range MMI value that typically represents streams that are on the borderline of meeting water quality goals for aquatic life uses (CT DEEP 2014). The percentage of values in the mid-range tended to decrease, while values on the higher and lower ends tended to stay the same between the two surveys.

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https://github.com/marybecker/ProbMonPrj