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NORTH COASTAL WATERSHED
2007 BENTHIC MACROINVERTEBRATE BIOASSESSMENT

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INTRODUCTION

Biological monitoring is a useful means of detecting anthropogenic impacts to the aquatic community. Resident biota (e.g., benthic macroinvertebrates, fish, periphyton) in a water body are natural monitors of environmental quality and can reveal the effects of episodic and cumulative pollution and habitat alteration (Plafkin et al. 1989, Barbour et al. 1995). Impacts to the benthic community may be indicated by the absence of generally pollution-sensitive macroinvertebrate taxa such as Ephemeroptera, Plecoptera, and Trichoptera (EPT); dominance of a particular taxon, especially the pollution-tolerant Chironomidae and Oligochaeta taxa; low total taxa richness; or shifts in community composition relative to the reference station (Plafkin, et al. 1989).

As part of the Massachusetts Department of Environmental Protection/Division of Watershed Management's (MassDEP/DWM) 2007 North Coastal Watershed assessments, aquatic benthic macroinvertebrate biomonitoring was conducted to evaluate the biological health of selected waterbodies and to determine their status with respect to the support of the *Aquatic Life* use, as designated in the *Massachusetts Surface Water Quality Standards* (SWQS) (MassDEP 2006). These assessments form the basis for reporting and listing waters pursuant to sections 305(b) and 303(d) of the Clean Water Act (CWA). A total of eight biomonitoring stations were sampled to determine the health of aquatic communities of the watershed (Appendix I, Figure 1). Appendix I, Table 1 presents the 2007 sampling locations, along with station identification numbers and sampling dates. Sampling rationale or known water quality issues for the 2007 North Coastal Watershed macroinvertebrate survey stations are presented in Appendix I, Table 2.

To provide information for making *Aquatic Life* use-support determinations, macroinvertebrate communities present at biomonitoring stations in the North Coastal Watershed were compared with communities occurring at a watershed reference station most representative of "least disturbed" conditions in the watershed. The watershed reference station (AL02A) was established on Alewife Brook.

METHODS

Macroinvertebrate Sampling - RBPIII

Macroinvertebrate sampling and habitat assessments were conducted on June 27th, 28th, and 29th at eight sites in the North Coastal Watershed (Appendix I, Table 1). Sampling activities were performed in accordance with the Sampling & Analysis Plan (SAP) for the North Coastal Watershed (MassDEP 2007). The sampling procedures are further described in the standard operating procedures *Water Quality Monitoring in Streams Using Aquatic Macroinvertebrates* (Nuzzo 2003), and are based on US EPA Rapid Bioassessment Protocols (RBPs) for wadeable streams and rivers (Plafkin, et al. 1989). The macroinvertebrate collection procedure utilized kick-sampling, a method of sampling benthic organisms by kicking or disturbing bottom sediments and catching the dislodged organisms in a net as the current carries them downstream. Sampling was conducted by MassDEP/DWM biologists throughout a 100 m reach, in riffle/run areas with fast currents and rocky (cobble, pebble, and gravel) substrates—generally the most productive habitats, supporting the most diverse communities in the stream system. Ten kicks in squares approximately 0.46 m x 0.46 m were composited for a total sample area of about 2 m^2. Samples were labeled and preserved in the field with denatured 95% ethanol, then brought to the MassDEP/DWM lab for further processing.

Macroinvertebrate Sample Processing and Data Analysis

The macroinvertebrate sample processing and analysis procedures employed for the 2007 North Coastal Watershed biomonitoring samples are described in the standard operating procedures (Nuzzo 2003). Macroinvertebrate sample processing entailed distributing whole samples in pans, randomly selecting grids within the pans, and sorting specimens from the other materials in the sample until approximately 100 organisms (±10%) were extracted. Specimens were identified to genus or species as allowed by available keys, specimen condition, and specimen maturity.

Based on the taxonomy, various community, population, and functional parameters, or "metrics", were calculated which allow measurement of important aspects of the biological integrity of the macroinvertebrate community. This integrated approach provides more assurance of a valid assessment because a variety of biological parameters are evaluated, and the deficiency of any one metric should not invalidate the entire approach (Plafkin, et al. 1989). Taxonomic data were analyzed using a modification of Rapid Bioassessment Protocol III (RBP III) metrics and scores (Plafkin, et al. 1989). The modifications were: substitution of "reference site affinity" (RSA) for the Community Loss Index and elimination of the shredder/total ratio (no separate leaf-pack material was collected). The reference site affinity metric is a modification of Percent Model Affinity (Novak and Bode 1992). Instead of using the model's percentages for Oligochaeta, Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Chironomidae, and "other," these percentages were taken from the reference site data. The RSA score is then calculated as:

$$100 - \Sigma (\delta \times 0.5)$$

where δ is the difference between the reference percentage and the sample percentage for each taxonomic grouping. RSA percentages convert to RBP III scores as follows: 0 points for <35%; 2 points in the range from 35 to 49%; 4 points for 50 to 64%; and 6 points if ≥65%. The entire suite of metrics used for the analysis was:

- Richness—the total number of different species present in the subsample plus those detected from a "large/rare" search of the whole sample (those taxa missed in subsampling);

- HBI—Hilsenhoff Biotic Index (Hilsenhoff 1982, 1987), as modified in Nuzzo (2003); the HBI is the sum of the products of each taxon's abundance and its corresponding pollution tolerance value, divided by the total count in the subsample;

- EPT—sum of richness among the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) as determined from the specimens in the subsample plus those detected in a "large/rare" search of the whole sample; these orders tend to be dominated by species generally considered to be pollution sensitive;

- $EPT_a/Chiro_a$—ratio of total abundance among EPT taxa to total abundance among Chironomidae taxa;

- SC/FC—ratio of the proportion of sample that is represented by individuals that predominantly feed by scraping to those that are primarily filter-feeders;

- % Dominant—most abundant taxon as a percent of the assemblage; >20% is generally considered hyperdominant and indicative of a stressor impact;

- RSA—reference site affinity (described above).

Metric values for each station were scored based on comparability to the reference station, and scores were totaled. The percent comparability of total metric scores for each study site to those for the selected "least-impacted" reference station yielded an impairment score for each site. RBP III analysis separates sites into four categories: "non-impaired", "slightly impaired", "moderately impaired", and "severely impaired". Each impairment category corresponds to a specific *Aquatic Life* use-support determination used in the CWA Section 305(b) water quality reporting process—non-impaired and slightly impaired benthic invertebrate communities are generally indicative of conditions supporting the *Aquatic Life* use, whereas water bodies exhibiting moderately or severely impaired communities are generally assessed as "non-support."

Habitat Assessment

Habitat qualities were scored for each sampling reach using the assessment procedure in Plafkin, et al. (1989), as modified in Barbour, et al. (1999). An evaluation of physical and biological habitat quality is

critical to any assessment of ecological integrity (Karr, et al. 1986; Plafkin, et al. 1989). Habitat assessment supports understanding of the relationship between physical habitat quality and biological conditions, identifies obvious constraints on the attainable potential of a site, assists in the selection of appropriate sampling stations, and provides basic information for interpreting biosurvey results (US EPA 1995). The matrix used to assess habitat quality is based on key physical characteristics of the water body and the immediate riverfront area. Most parameters evaluated are instream physical attributes that are potential sources of limitation to the aquatic biota (Plafkin, et al. 1989). The ten habitat parameters are as follows: instream cover, epifaunal substrate, embeddedness, sediment deposition, channel alteration, velocity/depth combinations, channel flow status, right and left bank vegetative protection, right and left bank stability, right and left bank riparian vegetative zone width. Habitat parameters are scored, totaled, and compared to the reference station to infer the extent to which the condition of the habitat, rather than water quality effects, may account for differences in macroinvertebrate community structure at the study sites.

RESULTS AND DISCUSSION

Habitat quality was impacted at a number of biomonitoring sites for a number of metrics (Appendix I, Table 3). Channel flow status scored poorly at the majority of stations. Crane Brook (CR02) exhibited particularly poor habitat quality and scored poorly on a number of metrics including sediment deposition, bank stability and riparian zone width.

A taxonomic list of the macroinvertebrate organisms collected at each sampling station during the 2007 biomonitoring survey is attached as an Appendix II. Included in the list are total organism counts, the functional feeding group designation (FFG) for each macroinvertebrate taxon, and the tolerance value (TV) of each taxon. Appendix I, Table 4 presents a summary of the RBP III macroinvertebrate data analyses for all sites. Included are biological metric calculations, metric scores, and impairment designations.

The benthic macroinvertebrate community at Station AL02A (Alewife Brook) was the designated reference for this survey (Appendix I, Table 4). This site exhibited the lowest HBI index of all sites sampled although 37% of the benthic community was composed of one taxon (*Chimarra aterrima*). The EPT index at the reference station was eight and generally all of the others site's had a low EPT index. One stonefly taxon, *Perlesta placida*, which has a relatively high tolerance value, was found at this station (Appendix II).

The macroinvertebrate communities present at four of the stations (CC01, CT01, HB01, and CR02) ranged from 32-42% comparable to the reference community, resulting in assessments of "moderately impaired" (Appendix I, Table 4). All of the impacted sites' EPT index scores compared poorly to the reference station. Given their low EPT index, the "moderately impaired" sites also compared poorly in terms of their EPT/Chironomidae ratio.

The unnamed tributary to Chubb Creek upstream from Oak Street, Beverly, MA (Station CC01) was dominated by one taxon, *Gammarus sp.*, which made up 65% of the community (Appendix II). The overall habitat score was reduced due to the following habitat metrics: instream cover, sediment deposition, bank vegetative protection and stability for the right bank as well as the riparian zone width on the right bank (Appendix I, Table 3). The unnamed Chubb Creek tributary is a very small stream and the watershed drainage area for the site is only 1.46 square miles (Appendix I, Table 5, USGS 2013). The benthic community appears structured in response both to habitat limitations and small watershed size.

The unnamed tributary to Beverly Cove locally known as "Curtis Brook" downstream from Tall Tree Drive, Beverly, MA (Station CT01) was 42% comparable to the reference station and considered "moderately impaired". The overall habitat score was reduced due to the following habitat metrics: instream cover for fish, sediment deposition, velocity/depth combinations and channel flow status (Appendix I, Table 3). The EPT index, EPT/Chironomidae metric, reference affinity metric and the percent dominant taxon metric all scored low (Appendix I, Table 4). The scraper/filterer metric is not applicable to the community at Station CT01 because no scraper taxa were present. Simuliidae, Gammaridae and Hydropsychidae made up

approximately 32%, 29% and 22% of the community, respectively. The watershed drainage area to this station is 1.34 square miles. The benthic community appears structured in response both to habitat limitations and small watershed size.

Hawkes Brook downstream/west of Walnut Street, Saugus, MA (Station HB01) was 42% comparable to the reference station and considered "moderately impaired". The overall habitat score was reduced due to the following habitat metrics: instream cover for fish, sediment deposition, velocity/depth combinations and bank stability and riparian zone width on the left bank (Appendix I, Table 3). The EPT index, EPT/Chironomidae metric, reference affinity metric and the percent dominant taxon metric all scored low (Appendix I, Table 4). *Gammarus sp*. made up 36% of the benthic community.

The watershed drainage area to station HB01 is 3.71 square miles and the predicted August streamflow that is exceeded 50 percent of the time is 0.51 cubic feet per second (cfs) (Appendix I, Table 5, USGS 2013). Obvious potential sources of nonpoint pollution included road runoff and instream trash. Habitat limitations appear to play an important role in the structure of the benthic community at this station.

Crane Brook, approximately 100m downstream from Pine Street, Danvers, MA (Station CR02) was 42% comparable to the reference station and considered "moderately impacted". The overall habitat score was reduced by the majority of parameters (Appendix I, Table 3). The EPT index, reference affinity metric and the percent dominant taxa metric all scored low (Appendix I, Table 4). *Gammarus sp*. made up 70% of the benthic community. The watershed drainage area to station CR02 is 2.69 square miles and the urban land use is approximately 80% (Appendix I, Table 5, USGS 2013). The predicted August streamflow that is exceeded 50 percent of the time is 0.73 cubic feet per second (cfs) (Appendix I, Table 5, USGS 2013).

Crane Brook upstream of Station CR02 has obviously been channelized in the past and is located in a highly urbanized setting. Samples with high *E. coli* bacteria counts were collected in Crane Brook at water quality station CR02 during 2007 sampling (MassDEP 2012). This, along with elevated specific conductivity measured at the water quality station, is indicative of water quality problems (MassDEP 2012). The benthic community appears to be principally structured in response to habitat limitations although water quality and quantity are also likely limiting factors.

Beaver Brook, approximately 150m downstream/south from the Route 62 crossing near the northern end of Roosevelt Avenue, Danvers, MA (Station BB02), was considered "slightly impaired" when compared to the reference station. The overall habitat score was reduced due to the following habitat metrics: instream cover, epifaunal substrate, velocity/depth combinations and channel flow status (Appendix I, Table 3). The EPT index, EPT/Chironomidae metric and reference affinity metric all scored low. This site and the reference site were the only sites at which the stonefly taxon, *Perlesta placida*, occurred.

Samples with high *E. coli* bacteria counts were collected in Beaver Brook at Pickering Street, Danvers (water quality station BB01) during 2007 sampling (MassDEP 2012). Dissolved oxygen concentrations during multiprobe deployments in July, August and September were often less than 5 mg/L and specific conductivity was elevated (MassDEP 2012). The water flow at this station was also noted to be stagnant during water quality surveys in September. Although water quality conditions show an impact at this station, it is important to note the small drainage area of the site. The watershed drainage area to station BB02 is 1.76 square miles and the urban land use is approximately 70% (Appendix I, Table 5, USGS 2013). The predicted August streamflow that is exceeded 50 percent of the time is 0.51 cubic feet per second (cfs) (Appenidx I, Table 5, USGS 2013). The Beaver Brook station has similar watershed characteristics as the Crane Brook station (Appendix I, Table 5) but has a greater habitat score, which may help explain its higher scoring benthic community.

The Frost Fish Brook station, approximately 150m upstream/north from Route 62, Danvers, MA (Station FF01), was considered "slightly impaired" when compared to the reference station. The overall habitat score was reduced due to the following habitat metrics: sediment deposition, velocity/depth combinations, bank stability and bank vegetative protection and riparian zone width on the right bank (Appendix I, Table 3). The EPT index, EPT/Chironomidae metric and reference affinity metric all scored low. With the

exception of samples with high *E. coli* bacteria counts collected at this station, water quality was generally acceptable (MassDEP 2012).

Frost Fish Brook upstream of the sampling station is located in a residential neighborhood in Danvers and is highly channelized. The watershed drainage area to station FF01 is 2.90 square miles and the urban land use is approximately 80% (Appendix I, Table 5, USGS 2013). The predicted August streamflow that is exceeded 50 percent of the time is 0.55 cubic feet per second (cfs) (Appendix I, Table 5, USGS 2013).

The Crane River station, approximately 10m upstream/west from Ash Street, Danvers, MA (Station CR01), was considered "slightly impaired" when compared to the reference station. The overall habitat score was reduced due to the following habitat metrics: instream cover, velocity/depth combinations, channel flow status and bank stability (Appendix I, Table 3). Serious channel degradation and incision was noted. The EPT index, reference affinity metric and percent dominant taxon all scored low while other benthic metrics scored similarly to the reference station (Appendix I, Table 4). Approximately 90% of the individuals found had a tolerance value 5–7 and sensitive taxa are noticeably absent (Appendix II).

The watershed drainage area to station CR01 is 5.26 square miles and the urban land use is approximately 80% (Appendix I, Table 5, USGS 2013). The predicted August streamflow that is exceeded 50 percent of the time is 1.59 cubic feet per second (cfs) (Appendix I, Table 5, USGS 2013). With the exception of samples with high *E. coli* bacteria counts collected at this station, water quality was generally acceptable (MassDEP 2012). The watershed area and predicted streamflow at this station is similar to that of the reference stream, Alewife Brook.

SUMMARY AND RECOMMENDATIONS

Sampling of the benthic macroinvertebrate community was carried out in June 2007 at eight sites in the North Coastal Watershed to evaluate the biological health of selected streams and to determine their status with respect to the support of the *Aquatic Life* use. Results of these assessments form the basis for reporting and listing waters under sections 305(b) and 303(d) of the Clean Water Act. In addition, some sites were chosen to evaluate the potential effects of particular activities within their watersheds. Field and laboratory methods and data analysis were based on the USEPA's Rapid Biomonitoring Protocols.

Station AL02A on Alewife Brook, served as the reference site. All of the benthic stations, when compared to the reference station scored, poorly in terms of the EPT index. The Alewife Brook station had eight EPT taxa while the majority of stations had few or no EPT taxa. The majority of water bodies were "moderately impaired" when compared to the reference site. The RBPIII analysis for stations CC01, CT01, HB01, CR02 is confounded by the small watersheds draining to these stations and their low streamflows. Habitat limitations were also an issue at all of these stations. Given the multiple factors which are shaping the benthic communities at the "moderately impaired" stations, it is likely that compromised habitat, small watershed size and nonpoint source pollution all contributed to the poor ecosystem health.

The benthic communities at the Beaver Brook, Frost Fish Brook and Crane River stations were considered "slightly impaired" when compared to the reference station at Alewife Brook. Beaver Brook and Frost Fish Brook had similar watershed characteristics as some of the benthic stations that were considered "moderately impaired". The benthic community at the "slightly impaired" stations tended to have lower percent dominant taxa and greater reference affinity than the "moderately impaired" sites. All of the stations sampled had an elevated biotic index and generally lacked intolerant taxa.

The RBPIII analysis in the North Coastal watershed may be confounded by the fact that many of the streams are small and subject to low flows. Further research aimed at defining reference conditions in the coastal plain ecoregion of Massachusetts would provide a more robust analysis of the true condition of the benthic community in streams throughout the North Coastal watershed.

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APPENDIX I: Tables and Figures

Table 1. List of biomonitoring stations sampled during the 2007 North Coastal Watershed survey, including station and unique identification numbers, drainage areas, sampling site descriptions, and sampling dates.

Station ID	Unique ID	Drainage area (mi^2)	North Coastal Watershed Site description	Sampling Date
AL02A[1]	B0619	6.77	**Alewife Brook** ~300 meters downstream/east from Apple Street, Essex, MA	27-Jun-2007
CC01	B0620	1.46	**Unnamed Chubb Creek tributary** ~5m upstream/northwest from Oak Street, Beverly, MA	27-Jun-2007
CT01	B0621	1.35	**Unnamed tributary to Beverly Cove locally known as "Curtis Brook"** ~200m downstream from Tall Tree Drive, Beverly, MA	27-Jun-2007
BB02	B0618	1.78	**Beaver Brook** ~150m downstream/south from the Route 62 crossing near the northern end of Roosevelt Avenue, Danvers, MA	28-Jun-2007
FF01	B0003	2.9	**Frost Fish Brook** ~150m upstream/north from Route 62, Danvers, MA	28-Jun-2007
CR01	B0002	5.26	**Crane River** ~10m upstream/west from Ash Street, Danvers, MA	28-Jun-2007
HB01	B0617	3.71	**Hawkes Brook** ~50m downstream/west of Walnut Street, Saugus, MA	29-Jun-2007
CR02	B0616	2.69	**Crane Brook** ~100m downstream from Pine Street, Danvers, MA	29-Jun-2007

[1] Reference station

Table 2. Sampling rationale for 2007 North Coastal Watershed biomonitoring survey. Sampling rationale detailed in North Coastal Watershed Sampling and Analysis Plan (MassDEP 2007).

North Coastal Watershed Stations	Sampling Rationale/Known Issues
AL02A[1]	**Alewife Brook** – Reference Station
CC01	**Unnamed Chubb Creek Tributary** – Assess aquatic life use
CT01	**Unnamed Tributary to Beverly Cove (aka Curtis Brook)** – Assess aquatic life use
BB02	**Beaver Brook** - Organic enrichment/Low DO, Pathogens
FF01	**Frost Fish Brook** - Pathogens
CR01	**Crane River** – Pathogens, Turbidity
HB01	**Hawkes Brook** - Pathogens
CR02	**Crane Brook** - Unionized Ammonia, Organic enrichment/Low DO, Pathogens, Suspended solids, Turbidity

[1] Reference station

Table 3. Habitat assessment summary for biomonitoring stations sampled during the 2007 North Coastal Watershed survey. For within-reach parameters, scores ranging from 16-20 = optimal; 11-15 = suboptimal; 6-10 = marginal; 0-5 = poor. For bank and riparian zone, scores ranging from 9-10 = optimal; 6-8 = suboptimal; 3-5 = marginal; 0-2 = poor. Maximum habitat score for any site = 200. Refer to Table 1 for a listing and description of sampling stations.

STATION	AL02A[1]	CC01	CT01	BB02	FF01	CR01	HB01	CR02
INSTREAM PARAMETERS (range is 0-20)	SCORE							
INSTREAM COVER	13	5	8	3	12	6	6	6
EPIFAUNAL SUBSTRATE	18	11	13	9	15	17	13	8
EMBEDDEDNESS	17	11	13	17	17	16	17	9
CHANNEL ALTERATION	13	11	18	13	13	11	18	11
SEDIMENT DEPOSITION	14	8	11	17	7	17	3	4
VELOCITY-DEPTH COMBINATIONS	14	12	10	6	10	9	7	7
CHANNEL FLOW STATUS	8	11	8	7	15	10	14	14
BANK AND RIPARIAN ZONE PARAMETERS (range is 0-10 for each bank)	SCORE							
BANK VEGETATIVE PROTECTION left	4	10	10	10	9	9	9	9
BANK VEGETATIVE PROTECTION right	9	4	8	9	4	9	9	9
BANK STABILITY left	10	9	7	10	3	3	5	3
BANK STABILITY right	6	5	7	8	5	3	8	3
RIPARIAN VEGETATIVE ZONE WIDTH left	10	10	10	9	10	8	3	5
RIPARIAN VEGETATIVE ZONE WIDTH right	10	1	7	7	2	10	10	3
TOTAL SCORE	**146**	**108**	**130**	**125**	**122**	**128**	**122**	**91**

[1] Reference station

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Table 4. Summary of RBP III analysis of macroinvertebrate communities sampled during the 2007 North Coastal Watershed survey. Shown are the calculated metric values, metric scores (in italics) based on comparability to the reference station (AL02A – Alewife Brook). Refer to Table 1 for a listing and description of sampling stations.

SAMPLING STATION	AL02A[1]		CC01		CT01		BB02		FF01		CR01		HB01		CR02	
STREAM	ALEWIFE BROOK		UNNAMED TRIBUTARY		UNNAMED TRIBUTARY		BEAVER BROOK		FROST FISH BROOK		CRANE RIVER		HAWKES BROOK		CRANE BROOK	
HABITAT SCORE	146		108		130		125		122		128		122		91	
TAXA RICHNESS	13	*6*	18	*6*	14	*6*	14	*6*	15	*6*	12	*6*	16	*6*	8	*4*
BIOTIC INDEX	4.81	*6*	5.89	*4*	5.65	*6*	5.80	*4*	5.42	*6*	5.55	*6*	6.42	*4*	5.86	*4*
EPT INDEX	8	*6*	2	*0*	2	*0*	4	*0*	4	*0*	3	*0*	1	*0*	1	*0*
EPT/CHIRONOMIDAE	7.91	*6*	0.22	*0*	2.00	*2*	0.93	*0*	0.40	*0*	6.80	*6*	0.23	*0*	2.00	*2*
SCRAPER/FILTERER	0.19	*6*	0.06	*2*	**	*0*	0.59	*6*	1.47	*6*	1.05	*6*	0.08	*4*	3.00	*6*
REFERENCE AFFINITY	100%	*6*	14%	*0*	35%	*0*	44%	*2*	33%	*0*	48%	*2*	21%	*0*	15%	*0*
% DOMINANT TAXON	37%	*2*	65%	*0*	32%	*2*	24%	*4*	24%	*4*	43%	*0*	36%	*2*	70%	*0*
TOTAL METRIC SCORE	38		12		16		22		22		26		16		16	
% COMPARABILITY TO REFERENCE	100%		32%		42%		58%		58%		68%		42%		42%	
BIOLOGICAL CONDITION -DEGREE IMPACTED	Not Impaired		Moderately Impaired		Moderately Impaired		Slightly Impaired		Slightly Impaired		Slightly Impaired		Moderately Impaired		Moderately Impaired	

[1] Reference station

** No scraper taxa in sample, scraper/filterer metric not applicable

Table 5: Summary of USGS StreamStats Statistics for 2007 North Coastal Watershed Macroinvertebrate Sampling. Flow parameters for watersheds with drainage areas less than 1.61 square miles, the required minimum for USGS regression equations, were not calculated.

Unique ID	Station ID	Waterbody	Drainage Area (square miles)	Mean basin slope computed from 1:250K DEM (percent)	Area of sand and gravel deposits (percent)	Total stream length (miles)	Streamflow exceeded 50 percent of the time (cubic feet per second)	7-Day mean low-flow that occurs on average once in 2 years (cubic feet per second)	7-Day mean low-flow that occurs on average once in 10 years (cubic feet per second)	August streamflow exceeded 50 percent of the time (cubic feet per second)	Urban Landuse (percent)	Percentage of impervious area determined from NLCD 2001 impervious dataset (percent)
B0619	AL02A	Alewife Brook	6.8	2.0	32%	17.4	6.7	0.49	0.18	1.21	12	3.1
B0618	BB02	Beaver Brook	1.8	2.4	60%	2.9	1.7	0.22	0.1	0.51	72	31.3
B0620	CC01	Unnamed Tributary to Creek Chubb	1.5	2.2	31%	4.6	Not calculated	Not calculated	Not calculated	Not calculated	27	8.7
B0002	CR01	Crane River	5.3	2.2	65%	9.8	5.2	0.71	0.33	1.59	79	39.2
B0616	CR02	Crane Brook	2.7	2.1	62%	5.2	2.6	0.31	0.13	0.73	78	41.9
B0621	CT01	Unnamed Tributary to Beverly Cove	1.3	1.3	47%	4.7	Not calculated	Not calculated	Not calculated	Not calculated	38	13.0
B0003	FF01	Frost Fish Brook	2.9	2.0	29%	5.1	2.8	0.22	0.08	0.55	78	33.8
B0617	HB01	Hawkes Brook	3.7	2.73	18%	12.3	3.6	0.2	0.07	0.51	38	15.1

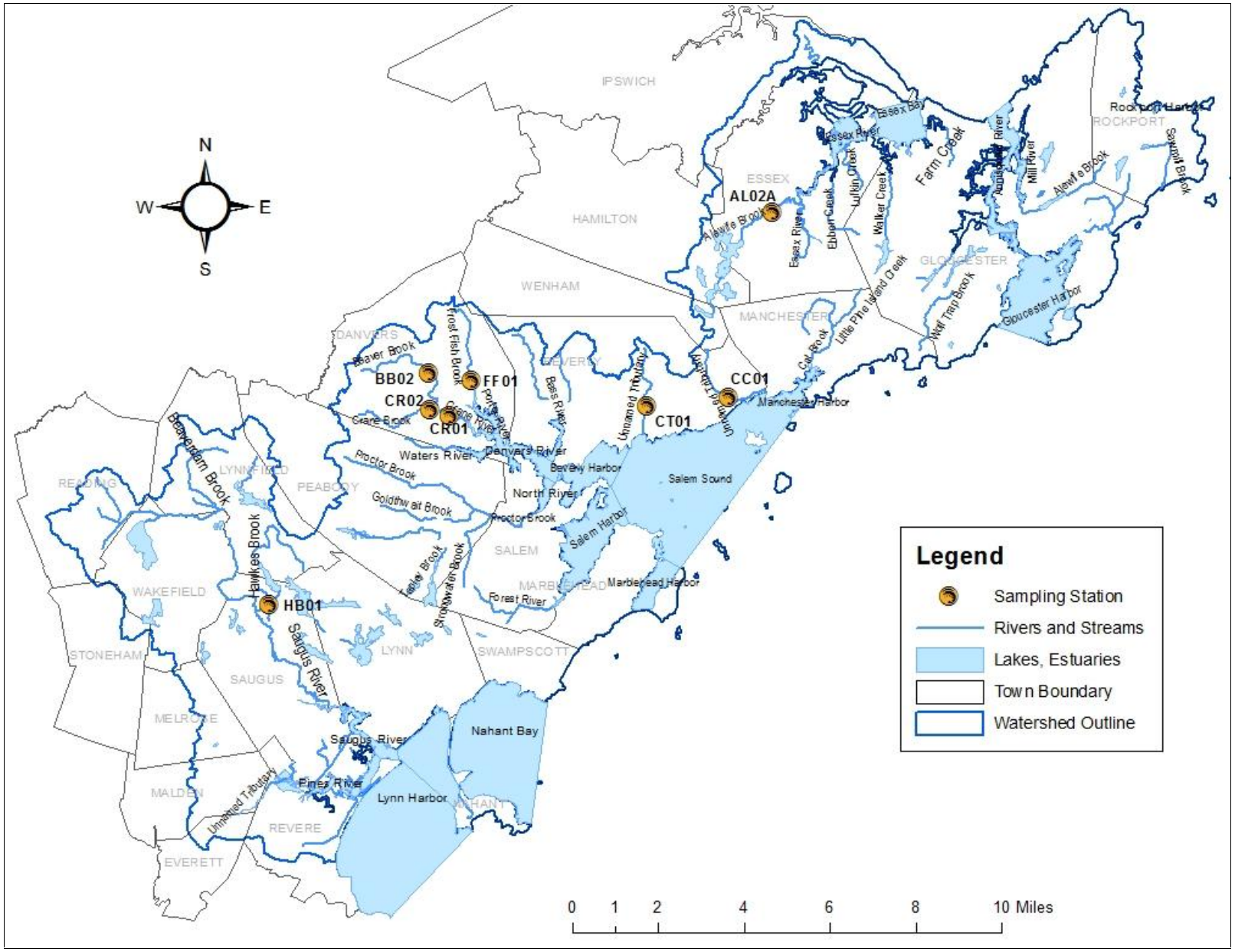

Figure 1: North Coastal Watershed Biomonitoring Stations

APPENDIX II: Taxa List

Species-level taxa list and counts, functional feeding groups (FFG), and tolerance values (TV) for macroinvertebrates collected from stream sites during the 2007 North Coastal Watershed survey between 27 and 29 June. Refer to Table 1 for a listing and description of sampling stations.

Class	Family	Taxon	FFG[1]	TV[2]	Sampling Sites							
					AL02A1[3]	CC01	CT01	BB02	FF01	CR01	HB01	CR02
Gastropoda	Physidae	Physidae	GC	8				7	1	1	9	
Gastropoda	Planorbidae	Planorbidae	SC	6		1						
Pelecypoda	Pisidiidae	Pisidiidae	FC	6		5	1				1	
Oligochaeta		Lumbricina	GC	8		3						
Oligochaeta	Enchytraeidae	Enchytraeidae	GC	10		1						
Oligochaeta	Naididae	Naididae	GC	9				1				
Oligochaeta	Naididae	*Nais elinguis*	GC	10						1		1
Oligochaeta	Tubificidae	Tubificidae	GC	10		1		3				
Oligochaeta	Lumbriculidae	Lumbriculidae	GC	7		1	2	1	2		1	4
Hirudinea	Erpobdellidae	*Erpobdella punctata*	PR	8			1					
Crustacea	Asellidae	*Caecidotea communis*	GC	8				1				
Crustacea	Asellidae	*Caecidotea racovitzai racovitzai*	CG	8							5	
Crustacea	Crangonyctidae	*Crangonyx* sp.	GC	6						1	1	
Crustacea	Gammaridae	*Gammarus* sp.	GC	6		66	32	26	23	8	35	74
Insecta	Baetidae	*Baetis* sp.	GC	6	5							
Insecta	Heptageniidae	*Maccaffertium modestum*	SC	1	2							
Insecta	Perlidae	*Perlesta placida*	PR	5	3			4				
Insecta	Glossosomatidae	*Glossosoma* sp.	SC	0				1	2			
Insecta	Hydropsychidae	Hydropsychidae	FC	4			6			4		
Insecta	Hydropsychidae	*Cheumatopsyche* sp.	FC	5	13	1	1	21	3	9	7	4
Insecta	Hydropsychidae	*Hydropsyche betteni*	FC	7	17	1	17	1	7	19		
Insecta	Limnephilidae	*Pycnopsyche sp.*	SH	4	2							
Insecta	Philopotamidae	*Chimarra aterrima*	FC	4	40				2			

Class	Family	Taxon	FFG[1]	TV[2]	Sampling Sites							
					AL02A1[3]	CC01	CT01	BB02	FF01	CR01	HB01	CR02
Insecta	Philopotamidae	*Chimarra obscura*	FC	4						2		
Insecta	Uenoidae	*Neophylax oligius*	SC	3	5							
Insecta	Elmidae	*Stenelmis* sp.	SC	5				12			1	18
Insecta	Elmidae	*Stenelmis crenata*	SC	5	7				23	43		
Insecta	Chironomidae	*Polypedilum aviceps*	SH	4		1	2					
Insecta	Chironomidae	*Polypedilum flavum*	SH	6			1	18	3	3		
Insecta	Chironomidae	*Polypedilum illinoense* gr.	SH	6		1					5	
Insecta	Chironomidae	*Micropsectra* sp.	GC	7							14	1
Insecta	Chironomidae	*Tanytarsus* sp.	FC	6			1					
Insecta	Chironomidae	*Diamesa* sp.	GC	5		1		8	1			
Insecta	Chironomidae	*Eukiefferiella claripennis* gr.	GC	8		1	2		1	1	3	
Insecta	Chironomidae	*Heterotrissocladius marcidus*	GC	4		1						
Insecta	Chironomidae	*Limnophyes* sp.	GC	8							1	
Insecta	Chironomidae	*Parametriocnemus* sp.	GC	5	2							
Insecta	Chironomidae	*Thienemanniella* sp.	GC	6					1			
Insecta	Chironomidae	*Tvetenia paucunca*	GC	5	9	3	5	3	25	1	2	
Insecta	Chironomidae	*Prodiamesa* sp.	GC	3		1						
Insecta	Chironomidae	*Thienemannimyia* gr.	PR	6			1		4		5	1
Insecta	Empididae	*Clinocera* sp.	PR	6	1							
Insecta	Psychodidae	*Psychoda* sp.	GC	10							1	
Insecta	Simuliidae	*Simulium* sp.	FC	5	2	11	35		5	7	5	2
Insecta	Tipulidae	*Dicranota* sp.	PR	3		2	2					
		Total			108	102	109	107	103	100	96	105

[1]Functional Feeding Group (FFG) lists the primary feeding habit of each species and follows the abbreviations: SH—Shredder; GC—Gathering Collector; FC—Filtering Collector; SC—Scraper; PR—Predator.

[2]Tolerance Value (TV) is an assigned value used in the calculation of the Biotic Index. Tolerance values range from 0 for organisms very intolerant of organic wastes to 10 for very tolerant organisms.

[3] Reference station