Table 1. List of Maine cold water preference taxa. Distribution and abundance information is also included. Sum_Individuals=the total number of individuals from that taxon in the Maine database; Pct_Abund=percent of total individuals in the database comprised of that taxon; Num_Stations=number of stations in the database that the taxon occurred at; Pct_Stations=percent of stations in the database at which the taxon occurred.

Type	Order	Family	FinalID	Sum_Individs	Pct_Abund	Num_Stations	Pct_Stations
cold	Ephemeroptera	Ameletidae	Ameletus	63	0.01	26	3.06
cold	Trichoptera	Apataniidae	Apatania	48	0.01	23	2.71
cold	Odonata	Aeshnidae	Boyeria	1761	0.3	321	37.81
cold	Plecoptera	Capniidae	Capnia	71	0.01	5	0.59
cold	Trichoptera	Hydropsychidae	Diplectrona	1137	0.19	47	5.54
cold	Ephemeroptera	Heptageniidae	Epeorus	2132	0.36	172	20.26
cold	Ephemeroptera	Ephemerellidae	Eurylophella	1785	0.3	170	20.02
cold	Trichoptera	Glossosomatidae	Glossosoma	945	0.16	119	14.02
cold	Diptera	Chironomidae	Heterotrissocladius	447	0.08	73	8.6
cold	Trichoptera	Limnephilidae	Hydatophylax	114	0.02	49	5.77
cold	Odonata	Gomphidae	Lanthus	36	0.01	11	1.3
cold	Diptera	Chironomidae	Larsia	269	0.05	58	6.83
cold	Plecoptera	Leuctridae	Leuctra	2407	0.4	142	16.73
cold	Trichoptera	Limnephilidae	Limnephilus	889	0.15	62	7.3
cold	Diptera	Chironomidae	Macropelopia	322	0.05	43	5.06
cold	Plecoptera	Perlodidae	Malirekus	0	0	0	0
cold	Trichoptera	Brachycentridae	Micrasema	405	0.07	87	10.25
cold	Diptera	Chironomidae	Natarsia	430	0.07	65	7.66
cold	Plecoptera	Nemouridae	Nemoura	17	0	4	0.47
cold	Megaloptera	Corydalidae	Nigronia	713	0.12	170	20.02
cold	Trichoptera	Phryganeidae	Oligostomis	485	0.08	87	10.25
cold	Coleoptera	Elmidae	Oulimnius	237	0.04	37	4.36
cold	Diptera	Chironomidae	Pagastia	420	0.07	96	11.31
cold	Trichoptera	Hydroptilidae	Palaeagapetus	1	0	1	0.12
cold	Plecoptera	Capniidae	Paracapnia	52	0.01	17	2

Table 1. continued…

Type	Order	Family	FinalID	Sum_Individs	Pct_Abund	Num_Stations	Pct_Stations
cold	Plecoptera	Nemouridae	Paranemoura	3	0	3	0.35
cold	Trichoptera	Hydropsychidae	Parapsyche	398	0.07	27	3.18
cold	Plecoptera	Peltoperlidae	Peltoperla	9	0	4	0.47
cold	Plecoptera	Perlodidae	Perlodidae	1775	0.3	212	24.97
cold	Diptera	Chironomidae	Prodiamesa	392	0.07	28	3.3
cold	Plecoptera	Nemouridae	Prostoia	6	0	1	0.12
cold	Diptera	Chironomidae	Pseudodiamesa	139	0.02	12	1.41
cold	Trichoptera	Limnephilidae	Psychoglypha	329	0.06	37	4.36
cold	Plecoptera	Pteronarcyidae	Pteronarcys	248	0.04	80	9.42
cold	Ephemeroptera	Heptageniidae	Rhithrogena	193	0.03	23	2.71
cold	Plecoptera	Chloroperlidae	Sweltsa	640	0.11	66	7.77
cold	Plecoptera	Taeniopterygidae	Taenionema	0	0	0	0
cold	Plecoptera	Peltoperlidae	Tallaperla	126	0.02	12	1.41
cold	Plecoptera	Capniidae	Utacapnia	71	0.01	3	0.35
cold	Plecoptera	Chloroperlidae	Utaperla	2	0	2	0.24
cold	Plecoptera	Nemouridae	Zapada	2	0	1	0.12

Table 2. List of Maine warm water preference taxa. Distribution and abundance information is also included. Sum_Individuals=the total number of individuals from that taxon in the Maine database; Pct_Abund=percent of total individuals in the database comprised of that taxon; Num_Stations=number of stations in the database that the taxon occurred at; Pct_Stations=percent of stations in the database at which the taxon occurred.

Type	Order	Family	FinalID	Sum_Individs	Pct_Abund	Num_Stations	Pct_Stations
warm	Plecoptera	Perlidae	Acroneuria	4857	0.82	331	38.99
warm	Mesogastropoda	Hydrobiidae	Amnicola	4589	0.77	160	18.85
warm	Odonata	Coenagrionidae	Argia	869	0.15	137	16.14
warm	Plecoptera	Perlidae	Attaneuria	172	0.03	36	4.24
warm	Ephemeroptera	Caenidae	Caenis	1783	0.3	169	19.91
warm	Diptera	Chironomidae	Cardiocladius	200	0.03	52	6.12
warm	Trichoptera	Leptoceridae	Ceraclea	876	0.15	152	17.9
warm	Haplotaxida	Naididae	Chaetogaster	342	0.06	70	8.24
warm	Diptera	Chironomidae	Dicrotendipes	1978	0.33	169	19.91
warm	Arhynchobdellida	Erpobdellidae	Erpobdella	265	0.04	65	7.66
warm	Basommatophora	Ancylidae	Ferrissia	594	0.1	102	12.01
warm	Trichoptera	Helicopsychidae	Helicopsyche	2563	0.43	104	12.25
warm	Basommatophora	Planorbidae	Helisoma	716	0.12	66	7.77
warm	Diptera	Empididae	Hemerodromia	1764	0.3	260	30.62
warm	Hydroida	Hydridae	Hydra	483	0.08	113	13.31
warm	Trichoptera	Hydroptilidae	Hydroptila	1799	0.3	189	22.26
warm	Ephemeroptera	Isonychiidae	Isonychia	5413	0.91	225	26.5
warm	Diptera	Chironomidae	Labrundinia	618	0.1	137	16.14
warm	Ephemeroptera	Heptageniidae	Leucrocuta	3320	0.56	208	24.5
warm	Trichoptera	Hydropsychidae	Macrostemum	4557	0.77	168	19.79
warm	Trichoptera	Polycentropodidae	Neureclipsis	15523	2.61	320	37.69
warm	Diptera	Chironomidae	Nilotanypus	413	0.07	133	15.67
warm	Trichoptera	Leptoceridae	Oecetis	3390	0.57	306	36.04
warm	Decapoda	Cambaridae	Orconectes	381	0.06	99	11.66

Table 2. continued…

Type	Order	Family	FinalID	Sum_Individs	Pct_Abund	Num_Stations	Pct_Stations
warm	Diptera	Chironomidae	Parachironomus	946	0.16	83	9.78
warm	Plecoptera	Perlidae	Paragnetina	625	0.11	103	12.13
warm	Diptera	Chironomidae	Pentaneura	881	0.15	139	16.37
warm	Basommatophora	Physidae	Physa	1373	0.23	115	13.55
warm	Basommatophora	Physidae	Physella	1681	0.28	155	18.26
warm	Ephemeroptera	Baetidae	Plauditus	1285	0.22	125	14.72
warm	Hoplonemertea	Tetrastemmatidae	Prostoma	267	0.04	61	7.18
warm	Diptera	Chironomidae	Psectrocladius	1693	0.28	161	18.96
warm	Ephemeroptera	Baetidae	Pseudocloeon	1147	0.19	113	13.31
warm	Diptera	Chironomidae	Rheopelopia	729	0.12	144	16.96
warm	Ephemeroptera	Ephemerellidae	Serratella	2534	0.43	191	22.5
warm	Ephemeroptera	Heptageniidae	Stenacron	6503	1.09	196	23.09
warm	Coleoptera	Elmidae	Stenelmis	2638	0.44	280	32.98
warm	Ephemeroptera	Heptagenidae	Stenonema	30768	5.18	536	63.13
warm	Diptera	Chironomidae	Tribelos	1781	0.3	78	9.19
warm	Ephemeroptera	Leptohyphidae	Tricorythodes	2655	0.45	205	24.15

Development of the Maine cold and warm water preference lists

Sources. The Maine cold and warm water lists were developed using several different sources: 1. weighted average calculations based on a subset of the Maine biomonitoring database (done by Lei Zheng of Tetra Tech, using site average temperature values (July, August, and September) from 616 sites); 2. the thermal preference trait from the Poff et al. 2006 traits matrix; 3. the thermal preference trait from the USGS traits database (Vieira et al. 2006); 4. the thermal preference trait from the compilation of EPA Environmental Requirements and Pollution Tolerance series from the late 1970's (Beck et al. 1977, Harris et al. 1978, Hubbard et al. 1978, Surdick et al. 1978); and 5. best professional judgment of the New England Climate Change traits feedback group.

Cold water designation. Taxa were placed on the Maine cold water list if they met the following criteria: 1. They received a rank temperature optima value of 1 or 2 or 3 (the rank optima value is based on percentiles of the dataset; for these taxa, the weighted average optima value was less than the 0.4 percentile value of the dataset it was derived from); or 2. the thermal preference in the Poff et al. 2006 traits matrix was 'cold_cool'; or 3. The thermal preference in the USGS traits database (Vieira et al. 2006) was 'cold stenothermal' or 'cold-cool eurythermal' (temperature preference of less than 15°C); or 4. The thermal preference in the EPA Environmental Requirements and Pollution Tolerance series (which were interpreted by Jen Stamp) was 'oligothermal' or 'stenothermal' or 'metathermal' (temperature preference of less than 15°C); or 5. If anyone in the New England Climate Change feedback group felt a taxon should be added to this list.

Warm water designation. Taxa were placed on the Maine warm water list if they met the following criteria: 1. They received a rank temperature optima value of 5 or 6 or 7 (the rank optima value is based on percentiles of the dataset; for these taxa, the weighted average optima value was greater than the 0.6 percentile value of the dataset it was derived from); or 2. the thermal preference in the Poff et al. 2006 traits matrix was 'warm'; or 3. The thermal preference in the USGS traits database (Vieira et al. 2006) was 'hot euthermal' or 'warm eurythermal' (temperature preference of greater than 15°C); or 4. The thermal preference in the EPA Environmental Requirements and Pollution Tolerance series (which were interpreted by Jen Stamp) was 'euthermal' or 'eurythermal' or 'mesothermal' (temperature preference of greater than 15°C); or 5. If anyone in the New England Climate Change feedback group felt a taxa should be added to this list.

Limitations. These lists were developed using the best information available, but it should be noted that the available information is limited. The weighted average calculations are based on instantaneous water temperature measurements that were taken at the time of the sampling event. Ideally continuous water temperature data could have been used, since this would provide more information about the thermal regime, especially during times of greatest thermal stress (i.e. summer baseflow conditions). The weighted average calculations also have limitations. One of the main concerns is that the analysis does not take into account the confounding factors ('noise') that are not related to temperature. However, with a sufficient amount of data, the noise essentially cancels itself out. Another limitation is that the operational taxonomic unit that was

most appropriate for this analysis is at the genus-level (in some instances, family-level was most appropriate). Within certain genera in particular, the thermal preference among species varies, so the assigned thermal preference may not be appropriate for all species within a genera. Attempts were made to note these genera.

We want to reiterate that when we developed these lists, we did the best we could with the data that was available. These lists should be viewed as a first step, not a final product. It would be very helpful if future research included a combination of short and long-term field and experimental studies designed to better evaluate climate change effects on freshwater ecosystems.

Initial Results. Initially there were 106 taxa on the cold water list and 82 taxa on the warm water list. These lists were based on weighted average calculations and literature. These lists were further refined through the evaluation of additional evidence, which included analyses of other datasets, case studies, and best professional judgment. Taxa with the greatest amount of evidence were assigned cold or warm water designations. More detailed information about the steps that were used to develop these lists is summarized below:

Considerations

A. Results from weighted average or maximum likelihood thermal optima and tolerance calculations were a major consideration. Results from the following eight analyses were used:

- California - Herbst and Silldorff (2007)
- Idaho - Brandt (2001)
- Maine – EPA GCRP Maine (2010) (based on site average temperature values (July-September) from 616 sites in the Maine biomonitoring database)
- North Carolina - EPA GCRP North Carolina (2010) (based on maximum likelihood calculations for the North Carolina biomonitoring database, full-scale collection method only)
- Ohio – Rankin and Yoder (2009)
- Oregon - Oregon DEQ (2008)
- Utah - EPA GCRP Utah (2010) (based on 572 fall samples from the Utah biomonitoring database)
- Western EMAP - Yuan (2006) (Estimation and Application of Macroinvertebrate Tolerance Values. Report No. EPA/600/P-04/116F)

A scoring system was developed to summarize results from the eight different analyses. It takes into account thermal preference, thermal tolerance and sample size. Scores were assigned (for each of the eight analyses) as follows:

COLD WATER TAXA

- 2=cold stenotherm (rank optima of 1 or 2 or 3 and rank tolerance of 1 or 2 or 3), adequate sample size (20 or more counts)
- 1=cold preference (rank optima of 1 or 2 or 3), adequate sample size (20 or more counts)
- 1=cold stenotherm (rank optima of 1 or 2 or 3 and rank tolerance of 1 or 2 or 3), low sample size (less than 20 counts)
- 0.5=cold preference (rank optima of 1 or 2 or 3), low sample size (less than 20 counts)

WARM WATER TAXA

- 2=warm eurythermal (rank optima of 5 or 6 or 7 and rank tolerance of 5 or 6 or 7), adequate sample size (20 or more counts)
- 1=warm preference (rank optima of 5 or 6 or 7), adequate sample size (20 or more counts)
- 1= warm eurythermal (rank optima of 5 or 6 or 7 and rank tolerance of 5 or 6 or 7), low sample size (less than 20 counts)
- 0.5=warm preference (rank optima of 5 or 6 or 7), low sample size (less than 20 counts)

In addition to the weighted average and maximum likelihood results, information on thermal preferences was also derived from literature. The taxon received a score of 1 if it was cited as a cold or warm water taxon in at least one of the following sources: Poff et al. 2006 traits matrix; or USGS traits database (Vieira et al. 2006); or EPA Environmental Requirements and Pollution Tolerance series from the late 1970's (Beck 1977, Harris et al. 1978, Hubbard et al. 1978, Surdick et al. 1978). If the weighted average results showed the taxon to have a preference for cold or warm water but the literature showed conflicting results (i.e. based on the weighted average results, the taxon was a cold water taxa, but the literature showed it to be a warm water taxa), then the taxon was not included on the cold or warm water list.

After scores were assigned as described above, they were summed so that each taxon received a total score. The higher the total score, the more evidence there was in the eight analyses and the literature that supported the designation of the cold or warm water taxa.

B. Several 'case studies' were performed to see whether the cold or warm water taxa occurred at sites in Maine and Vermont that had the warmest or coldest summer water temperatures. The following case studies were performed:

a. Cold Water Case Study #1. Vermont provided us with taxa lists from two sites that they regard as cold water habitat. They are located below a dam that does profundal releases, and the water temperature remains around 8°C year round. The dam is a confounding factor (although a study by the VT DEC indicates minor impacts on the

macroinvertebrate community from the whitewater releases), but temperature is regarded as a major factor influencing community composition at these sites.

b. Cold Water Case Study #2. Taxa lists from the following 3 sites in Maine: Station 57514 (Cold Brook (Dead River) – Maine DEP Station 772), Station 57513 (Cold Brook (Dead River) – Maine DEP Station 771) and Station 57512 (Cold Brook (Dead River) – Maine DEP Station 770). These sites were selected for the following reasons: 1. Water temperature readings at these 3 sites were among the lowest in the database, ranging from 7.8 to 13.9°C (these were July-Sept readings); based on the surrounding land use land cover (1km buffer), these sites appear to have few confounding factors (0-1% urban, 0% agricultural). Wetlands may influence the biota at these sites, especially Station 57512 (23% wetland), but temperature is believed to be a factor influencing community composition at these sites.

c. Warm Water Case Study #1. Taxa lists from two sites in Maine with the warmest average water temperatures: Station 56834 (Mattanawcook Stream – Maine DEP Station 91, below Lincoln Pulp and Paper (cooling water), which had an average summer water temperature of 31°C; and Site 57055 (Birch Stream (Bangor) – Maine DEP Station 312), which had an average summer water temperature of 30°C. These are not reference sites. Within the 1 km buffer, Station 56834 is 24% urban and Station 57055 is 60% urban.

d. Warm Water Case Study #2. Taxa lists from 5 sites in Maine with the warmest average water temperatures that were <5% urban and <10% agricultural within a 1 km buffer. Average water temperatures ranged from 26-27°C. Sites included: Station 57560 (West Seboeis Stream – Maine DEP Station 818), Station 56871 (Penobscot River - Maine DEP Station 128), Station 56953 (Dead River - Maine DEP Station 210), Station 57228 (Pollard Brook - Maine DEP Station 485) and Station 56952 (Dead River - Maine DEP Station 209).

C. In addition to the case studies, best professional judgment from the New England Climate Change group[1] was taken into account.

Development of the Cold Water Taxa List. Taxa were placed on the cold water list if the following criteria were met:

1. The taxon was NOT present at the warm water case study sites.

2. The taxon was present at one or more of the cold water case study sites and/or the New England Climate Change feedback group believed that it should be on the list.

[1] New England Climate Change group: Maine DEP (Leon Tsomides, Tom Danielson, Dave Courtemanche, Susan Davies), Vermont DEC (Doug Burnham, Steve Fiske, Jim Kellogg, Rich Langdon), New Hampshire (Dave Neils – NH DES, Don Chandler- UNH), Mike Winnell (professional taxonomist who works on a lot of Maine samples).

Development of the Warm Water List. Taxa were placed on the warm water list if the following criteria were met:

1. The taxon was NOT present at the cold water case study sites.

2. The taxon was present at one or more of the warm water case study sites and/or the New England Climate Change feedback group believed that it should be on the list.

Cold and Warm Water Lists. The cold water taxa list was comprised of 41 taxa and the warm water taxa list was comprised of 40 taxa. Lists can be found in **Tables 1** and **2**.

Important Notes – variation within genera. Some noteworthy genera were left off the Maine warm water list. These included Brachycentrus, Hydropsyche, and Ceratopsyche. Genera left off the Maine cold water list included Eukiefferiella and Rhyacophila. The reason they were not included is because there is variation in temperature preferences among species within these genera, and this was noted by the New England Climate Change feedback group or in the literature.

It is also worth noting the absence of two other genera from the cold water list – Antocha and Dicranota. In the weighted average and maximum likelihood analyses, these two taxa were often listed as cold water taxa. However, in the case studies, it became apparent that these genera were widespread and occurred at sites at which cold and warm temperatures had been recorded.

Abundance and Distribution. Those taxa that are widespread and common are likely to have greater genetic diversity and greater chance of adapting than rare taxa that only occur in isolated, localized populations (Sweeney et al. 1992). Moreover, the more abundant taxa are more likely to affect the state biomonitoring assessments. Abundance and distribution information for the cold and warm water taxa can be found in **Tables 1** and **2**.

The most abundant cold water preference taxa are Leuctra (Plecopteran), Epeorus (Ephemeropteran), Eurylophella (Ephemeropteran), Perlodidae (Plecopteran) and Boyeria (Odonata). These taxa comprise only 0.3 to 0.4% of the total individuals in the Maine database. Thirty-one of the cold water taxa have overall abundances of less than 0.1%. Stenonema and Neureclipsis are the most abundant warm water taxa, with overall abundances of 5.2 and 2.6%, respectively. Nine of the warm water taxa have overall abundances of less than 0.1%. Of the cold water taxa, Boyeria occurs at the largest percentage of sites (38%), followed by a Plecopteran, Perlodidae, which occurs at 25% of the sites. Thirty-one of the taxa occur at less than 10% of the sites. Among the warm water taxa, Stenonema occurs at the highest percentage of sites (63%), followed by Acroneuria (39%) and Neureclipsis (38%). Eight of the warm water taxa occur at less than 10% of the sites.

Additional information – Cold Water Taxa. Sixteen of the cold water taxa are Plecopterans, ten are Trichopterans, seven are Dipterans, and three are Ephemeropterans (**Table 3a**). The rest are Coleopterans, Odonates and Megalopterans. The families with the most number of taxa on the cold water list are Chironomidae and Nemouridae (**Table 3b**). It should be noted that two of the taxa on the cold water list, Malirekus and Taenionema, do not occur in the Maine database. They were added per best professional judgment of the Vermont DEC.

Additional information – Warm Water Taxa. Ten of the warm water taxa are Dipterans, nine are Ephemeropterans and six are Trichopterans (**Table 4a**). The families with the most number of taxa on the warm water list are Chironomidae and Perlidae (**Table 4b**).

Additional information – Species. Vermont DEC biologists suggested a list of species to include on the lists – see **Tables 5** and **6**)

Table 3a. Number of cold water taxa in each order.

Order	Total
Plecoptera	16
Trichoptera	10
Diptera	7
Ephemeroptera	3
Coleoptera	2
Odonata	2
Megaloptera	1

Table 3b. Number of cold water taxa in each family.

Family	Total
Chironomidae	7
Nemouridae	4
Capniidae	3
Limnephilidae	3
Chloroperlidae	2
Elmidae	2
Hydropsychidae	2
Peltoperlidae	2
Perlodidae	2
Aeshnidae	1
Ameletidae	1
Apataniidae	1
Brachycentridae	1
Corydalidae	1
Ephemerellidae	1
Glossosomatidae	1
Gomphidae	1
Heptageniidae	1
Hydroptilidae	1
Leuctridae	1
Phryganeidae	1
Pteronarcyidae	1
Taeniopterygidae	1

Table 4a. Number of warm water taxa in each order.

Order	Total
Diptera	10
Ephemeroptera	9
Trichoptera	6
Basommatophora	4
Plecoptera	3
Arhynchobdellida	1
Coleoptera	1
Decapoda	1
Haplotaxida	1
Hoplonemertea	1
Hydroida	1
Mesogastropoda	1
Odonata	1

Table 4b. Number of warm water taxa in each family.

Family	Total
Chironomidae	9
Perlidae	3
Physidae	2
Leptoceridae	2
Heptageniidae	2
Baetidae	2
Tetrastemmatidae	1
Polycentropodidae	1
Planorbidae	1
Naididae	1
Leptohyphidae	1
Isonychiidae	1
Hydroptilidae	1
Hydropsychidae	1
Hydrobiidae	1
Hydridae	1
Heptagenidae	1
Helicopsychidae	1
Erpobdellidae	1
Ephemerellidae	1
Empididae	1
Elmidae	1
Coenagrionidae	1
Cambaridae	1
Caenidae	1
Ancylidae	1

Table 5. Potential cold water ***species*** (per recommendation by Vermont DEC).

Order	Genus	Species
Diptera	Polypedilum	aviceps
Diptera	Neostempellina	reissi
Diptera	Tvetenia	bavarica
Ephemeroptera	Rhithrogena	sp
Ephemeroptera	Ameletus	sp
Trichoptera	Arctopsyche	sp
Trichoptera	Arctopsyche	ladogensis
Trichoptera	Rhyacophila	carolina
Trichoptera	Rhyacophila	torva
Trichoptera	Rhyacophila	nigrita
Trichoptera	Rhyacophila	invaria
Trichoptera	Rhyacophila	acutiloba
Plecoptera	Peltoperla	sp
Plecoptera	Tallaperla	sp
Plecoptera	Taenionema	sp
Decapoda	Cambarus	Cambarus bartoni
Trichoptera	Palaeagapetus	sp
Diptera	Eukiefferella	brevicalar, brehmi, and tirolensis
Coleoptera	Oulimnius	latiusculus
Coleoptera	Promoresia	tardella

Table 6. Potential warm water ***species*** (per recommendation by Vermont DEC).

Order	Genus	Species
Diptera	Eukiefferella	claripennis
Diptera	Polypedilum	flavum
Diptera	Tvetenia	discoloripes
Trichoptera	Leucotrichia	sp
Trichoptera	Rhyacophila	mainensis
Trichoptera	Rhyacophila	manistee
Trichoptera	Rhyacophila	minora
Plecoptera	Neoperla	sp
Plecoptera	Taeniopteryx	sp

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