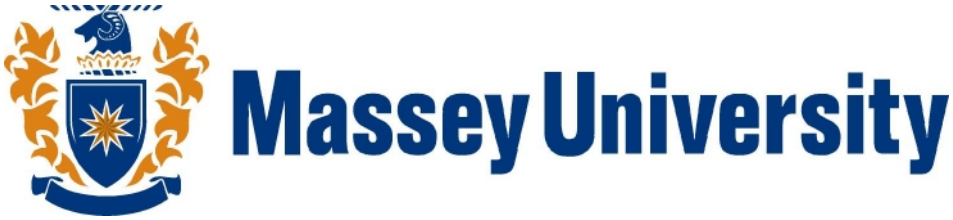
Environmental limits for invertebrates and fish living in aquatic ecosystem types within the Manawatu Wanganui Region



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Selection of representative taxa

A list of key invertebrate and fish taxa were compiled for streams and rivers falling into nine aquatic ecosystem types provided by Horizons Regional Council. Streams and rivers were sampled from a cross section of sites throughout the region thought to represent the "best management practice" for streams in those regions. Fish and invertebrates were sampled using standard sampling techniques outlined in Joy (2003).

Invertebrate taxa found in each of the ecosystem types are listed below in Table 1 and fish in Table 4.

Table 1. Invertebrate taxa and overall abundance found in "best management practice" streams in each of nine ecosystem types throughout the Manawatu Wanganui Region. Taxa for which information is available on temperature and/or ammonia tolerances are highlighted in grey.

UHS taxa	Abund.	UHS Lime taxa	Abund.	UVA taxa	Abund.	UVM taxa	Abund.
Number of streams	32	**Number of streams**	2	**Number of streams**	26	**Number of streams**	22
Deleatidium spp.	1179	Aoteapsyche	10	Deleatidium spp.	632	Deleatidium spp.	667
Coloburiscus humeralis	234	Hydrobiosis	7	Coloburiscus humeralis	222	Coloburiscus humeralis	244
Nesameletus	30	Pycnocentrodes spp.	6	Nesameletus	129	Nesameletus	36
Zephlebia dentata	13	Aphrophila	16	Zephlebia dentata	8	Zephlebia	23
Austrolima	10	Elmidae	15	Austroclima	15	Austroclima	46
Neozephlebia scita	10	Oligochaete	7	Neozephlebia scita	6	Neozephlebia scita	26
Austroperla cyrene	22	Potamopyrgus	76	Austroperla cyrene	25	Austroperla cyrene	6
Megaleptoperla grandis	8			Megaleptoperla grandis	11	Stenoperla prasina	7
Stenoperla prasina	23			Stenoperla prasina	26	Zelandoperla spp.	27
Zelandoperla spp.	81			Zelandpbius spp	77	Aoteapsyche	109
Aoteapsyche	139			Zelandoperla spp.	159	Beraeoptera roria	17
Beraeoptera roria	33			Aoteapsyche	123	Confluens hamiltoni	9
Costachorema	8			Beraeoptera roria	78	Hydrobiosis	76
Helicopsyche	53			Costachorema	10	Olinga	86
Hydrobiosella stenocerca	6			Hydrobiosis	129	Oxyethira albiceps	17
Hydrobiosis	99			Neurochorema confusum	6	Psilochorema spp.	6
Olinga	146			Olinga	64	Pycnocentria spp	55
Orthopsyche	7			Psilochorema spp.	14	Pycnocentrodes spp.	19
Oxyethira albiceps	14			Pycnocentria spp.	43	Aphrophila	18
Psilochorema spp.	9			Pycnocentrodes spp.	23	Austrosimulium	39
Pycnocentrodes spp.	23			Aphrophila	47	Maoridiamesa	23
Aphrophila	38			Austrosimulium	13	Orthocladiinae	215
Austrosimulium	32			Eriopterini	15	Podonominae	22
Eriopterini	7			Maoridiamesa	65	Tanypodinae	6
Maoridiamesa	25			Orthocladiinae	172	Elmidae	169
Orthocladiinae	168			Podonominae	6	Hydraenidae	29

Podonominae	19			Tanypodinae	8	Archcauliodes diversus	65
Elmidae	325			Elmidae	259	Potamopyrgus	57
Hydraenidae	26			Hydraenidae	12		
Archcauliodes diversus	69			Archcauliodes diversus	91		
Amphipoda	118			Oligochaete	11		
Oligochaeta	48			Potamopyrgus	24		
Potamopyrgus	48						

UHS taxa	**Adund.**	**UHS Lime taxa**	**Abund.**	**UVA taxa**	**Abund.**	**UVM taxa**	**Abund.**
Deleatidium spp.	1179	Aoteapsyche	10	Deleatidium spp.	632	Deleatidium spp.	667
Coloburiscus humeralis	234	Hydrobiosis - early instar	7	Coloburiscus humeralis	222	Coloburiscus humeralis	244
Nesameletus	30	Pycnocentrodes spp.	6	Nesameletus	129	Nesameletus	36
Zephlebia	13	Aphrophila	16	Zephlebia	8	Zephlebia	23
Austroclima	10	Elmidae	15	Austroclima	15	Austroclima	46
Neozephlebia scita	10	Oligochaete	7	Neozephlebia scita	6	Neozephlebia scita	26
Austroperla cyrene	22	Potamopyrgus	76	Austroperla cyrene	25	Austroperla cyrene	6
Megaleptoperla grandis	8			Megaleptoperla grandis	11	Stenoperla prasina	7
Stenoperla prasina	23			Stenoperla prasina	26	Zelandoperla spp.	27
Zelandoperla spp.	81			Zelandobious spp.	77	Aoteapsyche	109
Aoteapsyche	139			Zelandoperla spp.	159	Beraeoptera roria	17
Beraeoptera roria	33			Aoteapsyche	123	Confluens hamiltoni	9
Costachorema - early instar	8			Beraeoptera roria	78	Hydrobiosidae - early instar	67
Helicopsyche	53			Costachorema - early instar	10	Hydrobiosis parumbripennis	9
Hydrobiosella stenocerca	6			Hydrobiosidae - early instar	107	Olinga	86
Hydrobiosidae - early instar	82			Hydrobiosis parumbripennis	22	Oxyethira albiceps	17
Hydrobiosis parumbripennis	9			Neurochorema confusum	6	Psilochorema spp.	6
Hydrobiosis frater group	8			Olinga	64	Pycnocentria spp.	54

Olinga	146
Orthopsyche	7
Oxyethira albiceps	14
Psilochorema spp.	9
Pycnocentrodes spp.	23
Aphrophila	38
Austrosimulium	32
Eriopterini	7
Maoridiamesa	25
Orthocladiinae	168
Podonominae	19
Elmidae	325
Hydraenidae	26
Amphipoda	118
Archcauliodes diversus	69
Oligochaete	48
Potamopyrgus	48

Psilochorema spp.	14
Pycnocentria spp.	43
Pycnocentrodes spp.	23
Aphrophila	47
Austrosimulium	13
Eriopterini	15
Maoridiamesa	65
Orthocladiinae	172
Podonominae	6
Tanypodinae	8
Chironomid pupae	8
Elmidae	259
Hydraenidae	12
Archcauliodes diversus	91
Oligochaete	11
Potamopyrgus	24

Pycnocentrodes spp.	19
Aphrophila	18
Austrosimulium	39
Maoridiamesa	23
Orthocladiinae	215
Podonominae	22
Tanypodinae	6
Chironomid pupae	11
Elmidae	169
Hydraenidae	29
Archcauliodes diversus	65
Potamopyrgus	57

Environmental tolerances for invertebrates

Very few of the taxa above have been examined for environmental tolerances. Tolerances for some that have been studied are given below.

Suspended sediments
Hickey (2000) recommends 5-15 NTU for "many" New Zealand stream invertebrates.

Ammonia
The table below includes a modified version of table 13.6 in Hickey (2000) and represents the sensitivity of selected invertebrates to ammonia.

Table 2 Sensitivity of selected invertebrates to ammonia. All concentrations are total ammonia with exposures at 15°C for 96 hours (except Amphipoda = 48 hours). The adjusted to pH 8 uses an algorithm given in US EPA 1998.

Taxa	pH	EC_{50} (mg N L-1)	Adjusted to pH 8 (mg N L-1)	References
Deleatidium sp.	7.6	35.5	17.5	Hickey & Vickers 1994
Zephlebia dentata	8	>30	>30	Hickey & Vickers 1994
Zelandobius furcillatus	8	>30	>30	Hickey & Vickers 1994
Pycnocentria evecta	7.6	32.9	16.3	Hickey & Vickers 1994
Potamopygrus antipodarum	7.6 - 8	16.5 - 19.9	9.8 - 16.5	Hickey & Vickers 1994
Paratya curvirostris	7.5 - 8.1	18.5 - 73.7	22.4 - 31.1	Richardson 1997, Hickey & Vickers 1994
Paracalliope fluviatilis (Amphipoda)	7.6	14.5	7.2	Hickey & Vickers 1994
Lumbriculus variegatus (Oligochaeta)	8	25.9	25.9	Hickey & Vickers 1994

Temperature
Quinn et al. (1994) suggest that 96 h LT_{50} (presented below) may be a few degrees higher than the temperatures limiting distribution in the field.

Table 3 LT_{50} temperatures for freshwater invertebrates after 96 hours. Temperatures were raised from 15°C by 2 to 4 °C every hour until the desired temperature was achieved (15, 20, 25, 30 or 35 °C).

	LT_{50} after 96 hours	Field survey observations	References
Stoneflies		< 19	Quinn & Hickey 1990
Deleatidium sp.	21-23		Quinn et al. 1994
Zephlebia dentata	23-24		Quinn et al. 1994
Zelandobius furcillatus	24-27		Quinn et al. 1994
Aoteapsyche	24-27		Quinn et al. 1994
Pycnocentrodes	30-35		Quinn et al. 1994
Pycnocentria evecta	20-29		Quinn et al. 1994
Elmidae	31-34		Quinn et al. 1994
Potamopygrus antipodarum	30-35		Quinn et al. 1994
Paratya curvirostris	24-27		Quinn et al. 1994
Paracalliope fluviatilis (Amphipoda)	23-25		Quinn et al. 1994
Lumbriculus variegatus (Oligochaeta)	25-29		Quinn et al. 1994

References

Hickey CW 2000. Ecotoxicology: laboratory and field approaches. In: Collier KJ, Winterbourn MJ ed. New Zealand stream invertebrates: ecology and implications for management. Christchurch, Caxton Press. Pp. 313-343.

Hickey CW, Vickers ML 1994. Toxicity of ammonia to nine native New Zealand freshwater invertebrate species. Archives of environmental contamination and toxicology 26: 292-298.

Joy MK 2003. The development of predictive models to enhance biological assessment of riverine systems in New Zealand. Unpublished PhD thesis, Massey University, Palmerston North. 188 p.

Richardson J 1997. Acute ammonia toxicity for eight New Zealand indigenous freshwater species. New Zealand Journal of Marine and Freshwater Research 31: 185-190.

Quinn JM, Hickey CW 1990. Characterisation and classification of benthic invertebrate communities in 88 New Zealand rivers in relation to environmental factors. New Zealand Journal of Marine and Freshwater Research 24: 387-409.

Quinn JM, Steele GL, Hickey CW, Vickers ML 1994. Upper thermal tolerances of twelve New Zealand stream invertebrate species. New Zealand Journal of Marine and Freshwater Research 28: 391-397.

Native fish

Table 4. Native fish taxa and overall abundance found in "best management practice" streams in each of nine ecosystem types throughout the Manawatu Wanganui Region. Taxa for which information is available on temperature and/or ammonia tolerances are highlighted in grey.

HM taxa	Abund.	HSS taxa	Abund.	LL taxa	Abund.	LM taxa	Abund.	LSC taxa	Abund.
Common Bully	9	Common Bully	48	banded kokopu	77	Common Bully	47	Inanga	20
Cran's bully	141	Cran's bully	260	koura	7	Cran's bully	43	Long fin eel	3
Elver	15	Elver	83	Long fin eel	2	Elver	39	Shrimp	199
Koaro	2	Inanga	262	Short fin eel	9	Inanga	84	Short fin eel	5
koura	54	koura	44			Koaro	31	Smelt	5
Long fin eel	117	Long fin eel	176			koura	31	Perch	5
Shrimp	17	Shrimp	2992			Long fin eel	156		
Red fin bully	28	Red fin bully	256			Shrimp	2390		
Short fin eel	2	Short fin eel	18			Red fin bully	47		
Short jaw kokopu	3	Short jaw kokopu	2			Short fin eel	24		
Brown trout	37	Brown trout	8			Short jaw kokopu	7		
Upland bullies	130	Upland bullies	109			Brown trout	5		
Torrent fish	10	Torrent fish	14			Upland bullies	117		
Dwarf galaxias	24	Mullet	2			Torrent fish	1		
Lamprey	9	Lamprey	2			Carp	6		
Nonmigratory bullies	271	Nonmigratory bullies	369			Nonmigratory bullies	158		

UHS taxa	Abund.	UHS Lime taxa	Abund.	UVA taxa	Abund.	UVM taxa	Abund.
Common Bully	3	Long fin eel	9	Cran's bully	19	Cran's bully	61
Cran's bully	2	Brown trout	4	Koaro	2	Inanga	1
Inanga	40			koura	22	koura	7
Koaro	8			Long fin eel	56	Long fin eel	61
koura	41			Brown trout	87	Shrimp	4
Long fin eel	52			Upland bullies	10	Red fin bully	1
Shrimp	1089			No Fish	1	Short jaw kokopu	1
Red fin bully	51			Nonmigratory bullies	29	Brown trout	32
Short fin eel	45					Upland bullies	71
Short jaw kokopu	25					Torrent fish	7
Brown trout	42					Nonmigratory bullies	132
Upland bullies	126						
Torrent fish	11						
Dwarf galaxias	8						
Lamprey	10						
Nonmigratory bullies	129						

Environmental tolerances for fish

Very few of the taxa above have been examined for environmental tolerances. Tolerances for some that have been studied are given below.

Ammonia
The table below includes a modified version of table 13.6 in Hickey (2000) and represents the sensitivity of selected invertebrates to ammonia.

Table 5 Sensitivity of selected fish to ammonia. All concentrations are total ammonia with exposures at 15°C for 96 hours. The adjusted to pH 8 uses an algorithm given in US EPA 1998.

Taxa	pH	EC_{50} (mg N L-1)	Adjusted to pH 8 (mg N L-1)	References
Common bully	7.5-8.1	82.3	37.8	Richardson 1997
Inanga	7.5-9	6.1-140.7	39.0-59.4	Richardson 1991
Red fin bully	8.1	34.1	41.2	Richardson 1997
Smelt	7.5	118.7	50.1	Richardson 1997
Short fin eel (elver)	7.5	224.9	95.0	Richardson 1997
Long fin eel (elver)	8.1	>44.4	>53.7	Richardson 1997

Temperature

Information in the table below is modified from Table 1 in Richardson et al. (1994)

Table 6 Upper lethal temperature and preferred temperature range. Temperature listed is the lowest value in Table 1 in Richardson et al (1994). Temperatures were assessed as either LT_{50} or CTM (critical thermal maximum) and from differing acclimation temperatures (more detail can be found in Richardson et al. (1994).

	Acclimated temp (°C)	Upper lethal temp (°C)	Method	Preferred temp. and quartiles (°C)	References
Short fin eel (elvers)	30	30.5	CTM	26.9 (25.6-28.5)	Simmons 1986
Short fin eel (adult)	15	39.7	LT_{50}	-	Richardson et al 1994
Long fin eel (elvers)	15	34.8	LT_{50}	24.4 (22.6-26.2)	Richardson et al 1994
Long fin eel (adult)	15	37.3	LT_{50}	-	Richardson et al 1994
Cran's bully (nonmigratory bully)	15	30.9	LT_{50}	21.0 (19.6-22.1)	Richardson et al 1994
Common bully	15	30.9	LT_{50}	20.2 (18.7-21.8)	Richardson et al 1994
Upland bully	15	32.8	CTM	-	Teale 1986

(nonmigratory bully)					
Torrentfish	15	30.0	LT_{50}	21.8 (20.1-22.9)	Richardson et al 1994
Inanga	15	30.8	LT_{50}	18.1 (17.2-19.1)	Richardson et al 1994
Shortjawed kokopu	16	29.0	LT_{50}	-	Main 1988
Koaro	16	27.0	LT_{50}	-	Main 1988
Commom smelt	15	28.3	LT_{50}	16.1 (15.1-17.4)	Richardson et al 1994

pH

Information on pH preferences for native fish are taken from West et al. (1997)

Table 7 Estimated pH preferences of some New Zealand native fish at 20°C. Modified from Table 1 in West et al (1997).

	Acclimation pH	pH range tested	pH preference Min	pH preference Max
Adults				
Inanga	7.91	5.0-11.2	5.2	10.9
Common bully	6.96	5.8-10.2	6.2	10.1
Common smelt	7.55	6.7-10.3	7.2	9.8
Redfinned bully	7.58	5.8-10.7	6.1	10.4
Juveniles				
Inanga	7.8	5.6-10.0	5.9	9.7
Common bully	7.94	5.2-10.8	6.1	10.6
Shortjawed kokopu	8.03	6.3-11.0	6.6	10.4
Banded kokopu	8.2	5.5-11.0	5.9	10.9
Koaro	7.99	5.2-10.9	5.7	10.7
Shortfinned elvers	7.86	3.2-10.0	3.3	9.8
Longfinned elvers	7.68	3.2-10.9	5.6	10.3

Dissolved oxygen

The main study on this is Dean & Richardson (1999) who found native fish to be surprisingly tolerant to low dissolved oxygen levels. They do not give specific oxygen levels for species of fish but recommend USEPA (1986) levels for Salmonid waters would be suitable for preserving native New Zealand fish (see table 8).

Table 8 Water column dissolved oxygen concentrations (mg / l) recommended by the USEPA (1986) to confer 5 levels of protection for waters containing salmonids. Modified from table 5 Dean & Richardson (1999).

Degree of impairment	Early life stages	Other life stages
None	11.0	8.0
Slight	9.0	6.0
Moderate	8.0	5.0
Severe	7.0	4.0
Acute limit	6.0	3.0

References

Dean TL, Richardson J 1999. Responses of seven species of native freshwater fish and a shrimp to low levels of dissolved oxygen. New Zealand Journal of Marine and Freshwater Research 33: 99-106.

Main MR 1988. Factors influencing the distribution of kokopu and koaro (Pisces: Galaxiidae). Unpublished Unpublished MSc thesis, University of Canterbury, Christchurch, New Zealand. 127 p.

Richardson J 1991. Acute toxicity of ammonia to juvenile inanga (*Galaxias maculatus)*. New Zealand Journal of Marine and Freshwater Research 25: 327-330.

Richardson J 1997. Acute ammonia toxicity for eight New Zealand indigenous freshwater species. New Zealand Journal of Marine and Freshwater Research 31: 185-190.

Richardson J, Boubee JAT, West DA 1994. Thermal tolerance and preference of some native New Zealand freshwater fish. New Zealand Journal of Marine and Freshwater Research 28: 399-407.

Simmons M 1986. Effects of elevated temperatures and thermal shock on fish larvae. Waikato Valley Authority technical publication. Waikato. Pp. 28.

Teale SS 1986. Effects of temperature on the survival, activity, and metabolic rate, of the upland bully, *Gobiomorphus breviceps*. Unpublished Unpublished MSc thesis, University of Canterbury, Christchurch, New Zealand. 138 p.

West DW, Boubee JAT, Barrier RFG 1997. Responses to pH of nine fishes and one shrimp native to New Zealand freshwaters. New Zealand Journal of Marine and Freshwater Research 31: 461-468.