

DRAFT Mountain Whitefish (*Prosopium williamsoni*) Thermal Tolerance Analyses – Juvenile and Adult, Summer
March 2016

Introduction

Recommended summer chronic and acute thermal tolerance values for juvenile and adult mountain whitefish trout and their justification are discussed below. The recommended tolerance values were developed in accordance with the “*DRAFT Methodology for Developing Thermal Tolerance Thresholds for Various Fish in Nevada – Juvenile and Adult, Summer*” (September 2015).

Chronic Thermal Tolerance Thresholds

Table 1 provides a summary of the range of chronic temperature tolerance values for mountain whitefish for various lines of evidence. These values are based upon a review of 4 papers and publications, the details of which are summarized in Attachment A.

There is obviously a wide range of temperatures from which to select an appropriate value and best professional judgment is called for. NDEP’s approach is to accept the EPA recommendations from Brungs and Jones (1977) unless the literature review provides a compelling reason to utilize other values. However in the case of mountain whitefish, EPA did not provide a chronic threshold recommendation. Brinkman et al. (2013) provided a chronic recommendation of 16.8°C calculated following EPA protocols. Brinkman et al. recommendations are deemed appropriate and therefore, it is recommended that a chronic thermal threshold of 17°C be utilized for mountain whitefish.

Table 1. Summary of Chronic Temperature Tolerances

Category	Temperature (°C)
Laboratory Optimal Growth Studies – Constant Temperature	
Optimum	13.8
Upper Optimum	18.8
Laboratory Temperature Preference Studies	
Average Preferences	9.6 – 17.4
Upper Preferences	13.8 – 23.0
Temperature Preference Field Studies	23.2
Thresholds from Others (Brinkman et al. (2013))	16.8
Recommended Chronic Temperature Tolerance (MWAT)	17.0

Acute Thermal Tolerance Thresholds

Table 2 provides a summary of the range of acute temperature tolerance values for mountain whitefish for various lines of evidence. These values are based upon a review of 3 papers and publications, the details of which are summarized in Attachment B.

As discussed in the methodology document, only the CTM values for acclimation temperature near the recommended chronic criterion (17°C) should be included in the acute criterion development process. However for mountain whitefish, CTM values were only available for acclimation temperatures 11 – 13.4°C. Generally, CTM values increase with increases in acclimation temperatures. Therefore, it could be assumed that CTM values associated with an acclimation temperature of 17°C would be higher than the 26.2 – 26.7°C range shown in Table 2.

Table 2. Summary of Acute Temperature Tolerances

Category	Temperature Tolerances (°C)	Potential Acute Criteria (°C)
Laboratory Lethal Studies – UILT/UUILT		
UUILT	22.6 – 23.6	20.6 – 21.6 ¹
Laboratory Lethal Studies – CTM		
Acclim. = 11 – 13.4°C	26.2 – 26.7	20.3 – 20.8 ²
Acclim. = 17°C	>26.7 ³	>20.8 ²
Thresholds from Others (Brinkman et al. (2013))		21.6
Recommended Acute Temperature Tolerance (MDMT)		22.0

¹UUILT values reduced by 2°C to provide 100% survival (See *Methodology*)

²CTM values reduced by 3.9°C to estimate quasi-UUILT values, and reduced by 2°C to provide 100% survival (See *Methodology*)

³No CTM values were only available for acclimation temperatures near 17°C. Generally, CTM values increase with increases in acclimation temperatures. Therefore, it could be assumed that CTM values associated with an acclimation temperature of 17°C would be higher than the 26.2 – 26.7°C range shown for acclimation temperatures of 26.2 – 26.7°C.

A review of the literature suggests that an appropriate acute criteria should fall between 20.3 and 21.6°C. NDEP’s approach is to accept the EPA recommendations from Brungs and Jones (1977) unless the literature review provides a compelling reason to utilize another value. However, in the case of mountain whitefish, EPA did not provide an acute thermal threshold recommendation. Brinkman et al. (2013) recommendations are deemed appropriate and therefore, it is recommended that an acute thermal threshold of 22°C be utilized for mountain whitefish.

References

Brinkman, S.F. and N.M.K. Viera. 2010. Water Pollution Studies. Federal Aid in Fish and Wildlife Restoration - Job Progress Report. Colorado Division of Wildlife, Aquatic Wildlife Research Section

Brinkman, S.F., H.J. Crockett and K.B. Rogers. 2013. Upper thermal tolerance of mountain whitefish eggs and fry. *Trans. Am. Fish. Soc.* 142:824-831.

Brungs, W.A. and B.R. Jones. 1977. Temperature Criteria for Freshwater Fish: Protocol and Procedures. EPA-600/3-77-061. Environmental Research Laboratory, Duluth, Minnesota.

Cadmus, P. 2015. Water Pollution Studies, Federal Aid in Fish and Wildlife Restoration - Job Progress Report. Colorado Parks and Wildlife, Aquatic Research Section.

Colorado Water Quality Control Division. 2007. Colorado temperature database.

Eaton, J.G., J.H. McCormick, B.E. Goodno, D.G. O'Brien, H.G. Stefan, M. Hondzo, and R.M. Scheller. 1995. A field information-based system for estimating fish temperature tolerances. *Fisheries* 20(4):10-18.

Inhat, J.M., and Bulkley, R.V. 1984. Influence of acclimation temperature and season on acute temperature preference of adult mountain whitefish, *Prosopium williamsoni*. *Environmental Biology of Fishes* 11(1):29-40.

Inhat, J.M., and Bulkley, R.V. 1984. Influence of acclimation temperature and season on acute temperature preference of adult mountain whitefish, *Prosopium williamsoni*. *Environmental Biology of Fishes* 11(1):29-40.

ATTACHMENT A

Detailed Summary of Chronic Thermal Tolerance Values for Mountain Whitefish, Juvenile and Adult, Summer

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Table A-1. Chronic Temperature Tolerances – Laboratory Optimal Growth Studies

Reference	Age or Size	Acclim. Temp. (°C)	Optimum Growth Temperature		Upper Optimum Growth Temperature	
			Temp. (°C)	Comment	Temp. (°C)	Comment
Brinkman and Viera (2010); Brinkman et al. (2013)	Fry	Unknown	13.8		18.8	Estimated temperature at growth rate = 80% of optimum

Table A-2. Chronic Temperature Tolerances – Laboratory Preference Studies

Reference	Age or Size	Acclim. Temp. (°C)	Average Preference Temperature		Upper Preference Temperature	
			Temp. (°C)	Comment	Temp. (°C)	Comment
Ihnat and Bulkley (1984)	Adult	9 - 15	12.6 – 17.4	Mean of modes; fish captured in October	15.9 – 23	Upper range of modes; fish captured in October
		4 - 15	9.6 - 12.6	Mean of modes; fish captured in December	13.8 – 19.5	Upper range of modes; fish captured in December
		4 - 15	9.9 – 11.4	Mean of modes; fish captured in February	15.0 – 16.5	Upper range of modes; fish captured in February
		7 - 15	11.1 – 16.4	Mean of modes; fish captured in April	14.8 – 22.9	Upper range of modes; fish captured in April

Table A-3. Chronic Temperature Tolerances – Field Studies

Reference	Temperature (°C)	Comment
Eaton et al. (1995)	23.2	Based upon 95 th percentile of 5% highest weekly average temperatures

Table A-4. Chronic Temperature Tolerances – Other Recommendations

Reference	Temperature (°C)	Comments
Brinkman (2013)	16.8	Calculated based upon Optimum and UUILT data

ATTACHMENT B

Detailed Summary of Acute Thermal Tolerance Values for Mountain Whitefish, Juvenile and Adult, Summer

DRAFT

Table B-1. Acute Temperature Tolerances – Laboratory Lethal Temperatures, UILT/UUILT

Reference	Size or Age	Acclim. Temp. (°C)	Test Duration	UILT		UUILT	
				Temp. (°C)	Comment	Temp. (°C)	Comment
Brinkman and Viera (2010); Brinkman et al. (2013)	Fry	See Note ¹	7-d			23.6	
			33-d			22.6	

¹Used the acclimated chronic exposure (ACE) thermal test method. Because the fish are gradually acclimated to the test temperatures, the acclimation and test temperature are the same for the ACE method. See the Methodology document for more details.

Table B-2. Acute Temperature Tolerances – Laboratory Lethal Temperatures, Critical Thermal Maximum

Reference	Size or Age	Acclim. Temp. (°C)	Rate	Temperature (°C)	Endpoint
Brinkman et al. (2013)	Fry	13.4	0.5°C/min (30°C/hour)	26.7	Loss of equilibrium
Cadmus (2015)	Young-of-year	11	0.3°C/min (18°C/hour)	26.2	Loss of equilibrium

Table B-3. Acute Temperature Tolerances – Other Recommendations

Reference	Temperature (°C)	Comments
Brinkman (2013)	21.6	Calculated based upon UUILT data