

**DRAFT Lahontan Cutthroat Trout (*Oncorhynchus clarkii henshawi*) Thermal Tolerance Analyses  
– Juvenile and Adult, Summer  
September 2016**

**Introduction**

Recommended summer chronic and acute thermal tolerance values for juvenile and adult Lahontan cutthroat 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 Lahontan cutthroat trout 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.

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 Lahontan cutthroat trout, EPA does not provide a chronic thermal threshold recommendation. As discussed in the methodology, chronic temperature criteria are generally not set to ensure the most optimum conditions. In fact, Brungs and Jones (1977) recommends chronic criterion for a given fish species that is between the optimum temperature and the UUILT. However, given that Lahontan cutthroat trout are classified as a threatened species by the US Fish and Wildlife Service, it is deemed appropriate to select a temperature criterion that is closer to the middle of the reported values. Therefore, NDEP recommends a chronic value of 17°C which is near the average values reported in the literature.

**Table 1. Summary of Chronic Temperature Tolerances**

<b>Category</b>	<b>Temperature (°C)</b>
Laboratory Optimal Growth Studies – Constant Temperature	
Optimum	12 - 22
Laboratory Optimal Growth Studies – Fluctuating Temperature	
Optimum mean temperature	17.7 (15 – 21 daily fluctuation)
Temperature Preference Field Studies	17.5 (avg.) – 20.9 (maximum)
Thresholds from Colorado (MWAT)	17
<b>Recommended Chronic Temperature Tolerance (MWAT)</b>	<b>17</b>

## Acute Thermal Tolerance Thresholds

Table 2 provides a summary of the range of acute temperature tolerance values for Lahontan cutthroat trout for various lines of evidence. These values are based upon a review of 7 papers, publications and other information, the details of which are summarized in Attachment B.

As discussed in the methodology document, only the UILT values for acclimation temperature near the recommended chronic criterion (17°C) are to be included in the acute criterion development process. However, with Lahontan cutthroat trout, all the Incipient Lethal Temperature studies were nontraditional<sup>1</sup> ACE (acclimated chronic exposure) studies with fish acclimated at an initial temperature (13 - 16°C) and then slowly exposed to ever increasing temperatures. Because the fish are gradually acclimated to the test temperatures, the acclimation and test temperature are the same. As a result the acclimation temperatures varied throughout the studies ranging from 13 - 16°C to values as high as 24°C or more. Since the recommended chronic criterion of 17°C is within this range, the UILT values from these studies were used for acute criterion derivation.

**Table 2. Summary of Acute Temperature Tolerances**

Category	Temperature Tolerances (°C)	Potential Acute Criteria (°C)
Laboratory Lethal Studies – UILT/UUILT		
UILT		
Acclim. = All temperatures	21.8 – 25.5	19.8 – 23.5 <sup>1</sup>
Field Studies	<26	
Other Information	21 - 22	
Thresholds from Colorado and Oregon	20.8 – 22.1	
<b>Recommended Acute Temperature Tolerance (MDMT)</b>	<b>22</b>	

<sup>1</sup>UILT and UUILT values reduced by 2°C to provide 100% survival (See *Methodology*)

A review of the literature suggests that an appropriate acute criterion should fall between 19.8 and 26°C. This is obviously a wide range 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 another value. However, in the case of Lahontan cutthroat trout, EPA did not provide an acute thermal threshold recommendation. Based upon the available information, NDEP concluded that an acute thermal tolerance value of 22°C is appropriate. This is consistent with a MDMT criterion recommendation (22°C) by Dunham (1999) for the State of Oregon.

<sup>1</sup> Under the traditional Incipient Lethal Temperature test, fish experience abrupt temperature changes when moved from acclimation tanks to the test water tanks. This precludes fish from acclimating to the gradually changing temperatures occurring in most natural conditions.

## References

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**ATTACHMENT A**

**Detailed Summary of Chronic Thermal Tolerance Values for Lahontan Cutthroat Trout, 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
<b><i>Constant Temperature Studies</i></b>						
Dickerson and Vinyard (2001)	Juvenile	13	13 - 22 <sup>1</sup>	No significant difference in growth at temperatures 13 - 22°C	<24	Growth dropped significantly at 24°C.
Meeuwig et al. (2004)	Juvenile	12	12 - 18 <sup>2</sup>	Highest growth rates	<24	Growth dropped significantly at 24°C.
<b><i>Fluctuating Temperature Studies</i></b>						
Meeuwig et al. (2004)	Juvenile	12	Diel fluctuation = 15 - 21; mean = 17.7	Growth rate was significantly higher at a cycle of 15-21°C than at a cycle of 12-24 °C.		

<sup>1</sup>Tests were performed at 13, 20, 22 and 24°C.

<sup>2</sup>Tests were performed at 12, 18 and 24°C.

**Table A-2. Chronic Temperature Tolerances – Field Studies**

<b>Reference</b>	<b>Temperature (°C)</b>	<b>Comment</b>
Dunham et al. (2001)	17.5	Average MWAT for distribution limits
	20.9	Maximum MWAT for distribution limits

**Table A-3. Chronic Temperature Tolerances – Colorado**

<b>Reference</b>	<b>Temperature (°C)</b>	<b>Comments</b>
Colorado WQCD (2007)	17	Recommended level as MWAT; Based upon literature review for variety of cutthroat trout subspecies

**ATTACHMENT B**

**Detailed Summary of Acute Thermal Tolerance Values for Lahontan Cutthroat Trout, 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
Dickerson and Vinyard (1999) <sup>1,2</sup>	Juvenile	13 <sup>1</sup>	7-day	25.5 <sup>2</sup>	Estimated based upon other study results		
Robinson (2010) <sup>3</sup>	Juvenile	12.5 <sup>3</sup>	<1-day	<26 <sup>3</sup>	100% mortality		
Vigg and Koch (1980) <sup>4</sup>	Juvenile	16 <sup>4</sup>	321 – 381.1 hours (mean time to death)	21.8 – 23.0	Mean lethal temperature (Truckee River water)		

<sup>1</sup>Following acclimation, temperatures were slowly increased (4°C/day) until the target temperatures were reached. Target temperatures were maintained for 7 days or until all fish died, whichever came first.

<sup>2</sup>UILT (50% mortality) estimated by NDEP at 25.5°C based upon following results: 0% mortality at 24°C; 60% mortality at 26°C; 100% mortality at 28°C.

<sup>3</sup>Following acclimation, temperatures were slowly increased (4°C/day) until the target temperature (26°C) was reached. Once the target temperature was obtained, all fish died in less than 1-day. No specific UILT value can be determined.

<sup>4</sup>Following acclimation, temperature was slowly increased (1°C/day) until the 1st target temperature target (20°C ) was reached, then held for 96 hours at each of the 20, 21, 22 and 23°C levels in sequence.



**Table B-2. Acute Temperature Tolerances – Field Studies**

<b>Reference</b>	<b>Temperature (°C)</b>	<b>Comments</b>
Dunham (2003)	<26	Occurrence of LCT more likely at sites with MDMT < 26°C

**Table B-2. Acute Temperature Tolerances – Other Information**

<b>Reference</b>	<b>Temperature (°C)</b>	<b>Comments</b>
Behnke and Zarn (1976)	21 - 22	According to Behnke and Zarn, present populations of cutthroat trout (including Lahontan cutthroat trout and other subspecies) these trout probably cannot persist in waters where maximum temperatures consistently exceed 21 - 22°C.

**Table B-2. Acute Temperature Tolerances –Colorado and Oregon**

Reference	Temperature (°C)	Comments
Colorado WQCD (2007)	22.1	Recommended level as DM. Based upon literature review for variety of cutthroat trout subspecies
State of Oregon (2016); Dunham (1999)	20	7-day average of daily maximums (MWMT)
	20.8	NDEP estimated MDMT values using Standardization conversion discussed in <i>Methodology</i> document (MDMT = 1.04 x MWMT)
Dunham (1999)	22	Recommended to State of Oregon as Daily Maximum criteria; Per Dunham (1999) - "To minimize risk of mortality and sublethal thermal stress for LCT, water temperatures should not exceed a daily maximum of 22°C."

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