

DRAFT Brown Bullhead (*Ameiurus nebulosus*) Thermal Tolerance Analyses – Juvenile and Adult, Summer
June 2016

Introduction

Recommended summer chronic and acute thermal tolerance values for juvenile and adult brown bullhead 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 brown bullhead for various lines of evidence. These values are based upon a review of 6 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 brown bullhead, EPA did not recommend a chronic thermal threshold. 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. Therefore, NDEP recommends a chronic value of 30°C which is within the upper range of the tolerances taken from the literature.

Table 1. Summary of Chronic Temperature Tolerances

Category	Temperature (°C)
Laboratory Optimal Growth Studies – Constant Temperature	
Optimum	25 – 30
Upper Optimum	>30
Laboratory Temperature Preference Studies	
Average Preferences	15.5 – 29.5
Upper Preferences	28.4 – 31.5
Final Preferendum	27.3 – 31
Temperature Preference Field Studies	29.5
Thresholds from EPA and Colorado (MWAT)	28.6
Recommended Chronic Temperature Tolerance	30

Acute Thermal Tolerance Thresholds

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

For ease of presentation, the UILT values have been summarized by acclimation temperature ranges (no studies were found which examined the Critical Thermal Maximum of juvenile/adult brown bullhead. However as discussed in the methodology document, only the UILT values for acclimation temperature near the recommended chronic criterion (30°C) are to be included in the acute criterion development process. For brown bullhead, UILT values for acclimation temperatures 25 – 30°C are utilized for criterion development.

Table 2. Summary of Acute Temperature Tolerances

Category	Temperature Tolerances (°C)	Potential Acute Criteria (°C)
Laboratory Lethal Studies – UILT/UILT		
UILT		
Acclim. = 5 – 10°C	28.9 – 29.1	
Acclim. = 10 – 15°C	29.1 – 32.9	
Acclim. = 15 – 20°C	33.2 – 35.3	
Acclim. = 20 – 25°C	33.4 – 35.5	
Acclim. = 25 – 30°C	35.3 ¹	33.3
Acclim. = 30 – 36°C	36.9 – 37.5	
Thresholds from Colorado		33.0
Recommended Acute Temperature Tolerance		33

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

A review of the available studies suggest that an appropriate acute criteria should fall around 33°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, no acute recommendation was provided by EPA for brown bullhead. Based upon the available information, NDEP concluded that an acute thermal tolerance value of 33°C is appropriate.

References

- Brett, J. R. 1944. Some lethal temperature relations of Algonquin Park fishes. University of Toronto Press.
- 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.
- Colorado Water Quality Control Division. 2007. Colorado temperature database.
- Crawshaw, L. I. 1975. Attainment of the final thermal preferendum in brown bullheads acclimated to different temperatures. *Comp. Biochem. Physiol.* 52A:171-173
- 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.
- Hart, J. S. 1947. Lethal temperature relations of certain fish of the Toronto region. *Transactions of the Royal Society of Canada* 5(41):57-71.
- Hart, J.S. 1952. Geographic variations of some physiological and morphological characters in certain freshwater fish. Ontario Fisheries Research Laboratory. University of Toronto Press.
- Keast, A. 1985. Growth responses of the brown bullhead (*Ictalurus nebulosus*) to temperature. *Can. J. Zool.* 63: 1510-1515.
- Reutter, J.M and C.E. Herdendorf. 1974. Laboratory estimates of the seasonal final temperature preferenda of some Lake Erie fish. *Proceedings of the 17th Conference on Great Lakes Research* 59-67.
- Richards, F.P., and R.M. Ibara. 1978. The preferred temperature of the brown bullhead, *Ictalurus nebulosus*, with reference to its orientation to the discharge canal of a nuclear power plan. *Trans. Am. Fish. Soc.* 107(2):288-294.

ATTACHMENT A

Detailed Summary of Chronic Thermal Tolerance Values for Brown Bullhead, 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
Keast (1985)	Year 0 and Year 2	5 - 30	25 - 30		>30	Maximum test temperature was 30°C. Higher test temperatures needed to characterize upper optimum

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

Reference	Age or Size	Acclim. Temp. (°C)	Average Preference Temperature		Upper Preference Temperature		Final Preferendum	
			Temp. (°C)	Comment	Temp. (°C)	Comment	Temp. (°C)	Comment
Crawshaw (1975)	Juvenile, adult	7 - 32	25 - 29.5				29 - 31	
Reutter and Herdenoff (1974)	Juvenile, adult	Within 2°C of ambient lake temperature	23.6 - 24.9		28.4 - 31.5	1 standard deviation above average preference		
Richards and Ibara (1978)	Juvenile, adult	3.5 - 28	15.5 - 26.5				27.3	

Table A-3. Chronic Temperature Tolerances – Field Studies

Reference	Temperature (°C)	Comment
Eaton et al. (1995)	29.5	Based upon 95 th percentile of 5% highest weekly average temperatures.

Table A-4. Chronic Temperature Tolerances – EPA and Colorado

Reference	Temperature (°C)	Comments
Colorado WQCD (2007)	28.6	Recommended level as MWAT

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ATTACHMENT B

Detailed Summary of Acute Thermal Tolerance Values for Brown Bullhead, Juvenile and Adult, Summer

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

Reference	Size or Age	Acclim. Temp. (°C)	Test Duration	UILT		UIILT	
				Temp. (°C)	Comment	Temp. (°C)	Comment
Brett (1944)	Juvenile	6	1-day	28.9			
		10	1-day	29.1			
		13	1-day	30 – 31			
		14	1-day	32.6 – 32.9			
		16	1-day	34.1			
		17	1-day	33.2			
		20	1-day	33.4 – 35.3			
		21	1-day	34.9			
		22	1-day	33.4 – 35.5			
		26	1-day	35.3			
		31.2	1-day	36.9			
		36	1-day	37.5			

Table B-2. Acute Temperature Tolerances – Colorado

Reference	Temperature (°C)	Comments
Colorado WQCD (2007)	33.0	Recommended level as DM