

DRAFT Walleye (*Sander vitreus*) Thermal Tolerance Analyses – Juvenile and Adult, Summer
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Introduction

Recommended summer chronic and acute thermal tolerance values for juvenile and adult walleye 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 walleye for various lines of evidence. These values are based upon a review of seven 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. EPA’s chronic value of 25°C falls within the range of potential criteria found in the literature, and is recommended as the chronic thermal tolerance level for adult/juvenile walleye. As discussed in the methodology, chronic temperature criteria are generally not set to ensure 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.

Table 1. Summary of Chronic Temperature Tolerances

Category	Temperature (°C)
Laboratory Optimal Growth Studies – Constant Temperature	
Optimum	22.1 – 26.0
Upper Optimum	26.0 – 28.0
Temperature Preference Field Studies	19 – 29
Thresholds from EPA and Colorado (MWAT)	25 – 28.5
Recommended Chronic Temperature Tolerance (MWAT)	25

Acute Thermal Tolerance Thresholds

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

For ease of presentation, the UILT and CTM values have been summarized by acclimation temperature ranges. However as discussed in the methodology document, only the UILT and CTM values for acclimation temperature near the recommended chronic criterion (25°C) are to be included in the acute criterion development process. For walleye, UILT and CTM values for acclimation temperatures 23 – 26°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/UUILT		
UILT		
Acclim. = 7 - 10°C	27.0 – 28.6	
Acclim. = 11 - 14°C	29.0 – 29.5	
Acclim. = 15 - 18°C	30.5 – 30.6	
Acclim. = 19 - 22°C	30.5 – 33.0	
Acclim. = 23 - 26°C	31.5 – 34.1	29.5 – 32.1 ¹
Acclim. = >26°C	34.1	
UUILT	31.6 – 34.1	29.6 – 32.1 ¹
Laboratory Lethal Studies – CTM		
Acclim. = 23°C	34.8 – 35.9	29.3 – 30.4 ²
Threshold from Colorado		32.0
Recommended Acute Temperature Tolerance (MDMT)		30

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

²CTM values reduced by 3.5°C to estimate quasi-UILT values. Quasi-UILT values then reduced by 2°C to provide 100% survival (See *Methodology*)

A review of laboratory studies suggests that an appropriate acute criterion should fall between 29.3 and 32.1°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 walleye, Brungs and Jones did not provide a recommended acute value. Therefore, it is recommended that a value of 30°C (roughly in the middle of the identified range) be used for the protection of juvenile/adult walleye.

References

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- Hokanson, K.E.F., Koest, W.M. 1986. Revised estimates of growth requirements and lethal temperature limits of juvenile walleyes. The Progressive Fish-Culturist 48:90-94.
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- Smith, L.L. Jr., and W.M. Koest. 1975. Temperature effects on eggs and fry of percoid fishes. US EPA, Duluth, Minn. Report EPA-660/3-75-017.
- Wilson SM, and Nagler J. 2006. Age, but not salinity, affects the upper lethal temperature limits for juvenile walleye (Sander vitreus). Aquaculture 257:187-193.

ATTACHMENT A

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

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

Reference	Age or Size	Acclim. Temp. (°C)	Optimum Growth Temperature		Upper Optimum Growth Temperature	
			Temp. (°C)	Comment	Temp. (°C)	Comment
Hokanson and Koenst (1986)	Juvenile	21	26.0		28.0	Estimated temperature at growth rate = 80% of optimum
Koenst and Smith, Jr. (1976)	Juvenile	na	22.1		26.0	Estimated temperature at growth rate = 80% of optimum
Smith, Jr. and Koenst (1975)	Juvenile		>25.2 or higher	Highest test temperature yielded the highest growth rate; actual optimum may be higher		

Table A-2. Chronic Temperature Tolerances – Field Studies

Reference	Temperature (°C)	Comment
Dendy (1948)	19 - 27	Temperature range for majority of fish
Eaton et al. (1995)	29.0	Based upon 95 th percentile of 5% highest weekly average temperatures

Table A-3. Chronic Temperature Tolerances – EPA and Colorado

Reference	Temperature (°C)	Comments
EPA (1977)	25	Recommended level as MWAT
Colorado WQCD (2007)	28.5	Recommended level as MWAT

ATTACHMENT B

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

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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
Hokanson and Koenst (1986) ¹	Juvenile	22.1	Unknown	33.0			
		26.0		34.1			
		28.0		34.1			
		NA	NA		34.1		
Koenst and Smith, Jr. (1976) ²	Juvenile	8	4-d	27.0			
		10.1		28.6			
		12.1		29.0			
		13.9		29.5			
		16.0		30.6			
		18.2		30.5			
		20.2		30.5			
		22.1		30.5			
		24.0		31.5			
25.8	31.6						
Wilson and Nagler (2006) ³	Sub-yearling	15-22	NA			34.1	
	Yearling	14-23				31.6	

¹Following acclimation, temperatures were slowly increased at 0.5°C/day until all the fish died.

²Following acclimation, temperatures were raised (at a rate of 3-4°C/hour) to the experimental temperatures and were then held for 96-hours.

³Following acclimation, temperatures were slowly increased at 1°C/day until all the fish died.

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

Reference	Size or Age	Acclim. Temp. (°C)	Rate	Temperature (°C)	Endpoint
Peterson (1993)	Juvenile	23	1°C/min (60°C/hour)	34.8 – 35.0	Loss of equilibrium
				35.8 – 35.9	Onset of spasms

Table B-3. Acute Temperature Tolerances – EPA and Colorado

Reference	Temperature (°C)	Comments
Colorado WQCD (2007)	32.0	Recommended level as DM

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