

DRAFT Fathead Minnow (*Pimephales promelas*) Thermal Tolerance Analyses – Juvenile and Adult, Summer
March 2016

Introduction

Recommended summer chronic and acute thermal tolerance values for juvenile and adult fathead minnow 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 fathead minnow for various lines of evidence. These values are based upon a review of 5 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 the fathead minnow, EPA has not recommended a chronic thermal tolerance value. Based upon the available data, the recommended chronic threshold for fathead minnow is 29°C. This value is consistent with the value established by the State of Colorado and in the upper range of potential criteria found in the literature. 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.

Table 1. Summary of Chronic Temperature Tolerances

| Category | Temperature (°C) |
|---|-------------------------|
| Laboratory Temperature Preference Studies | |
| Average Preferences | 8.8 – 29.3 |
| Upper Preferences | 14 – 31.1 |
| Final Preferendum | 23.4 |
| Laboratory Upper Temperature Avoidance Studies | 22 – 32 |
| Threshold from Colorado (MWAT) | 28.8 |
| Recommended Chronic Temperature Tolerance (MWAT) | 29 |

Acute Thermal Tolerance Thresholds

Table 2 provides a summary of the range of acute temperature tolerance values for fathead minnow for various lines of evidence. These values are based upon a review of twenty-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 (29°C) are to be included in the acute criterion development process. For fathead minnow, UILT and CTM 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/UUILT | | |
| UILT | | |
| Acclim. = 5 – 10°C | 26.1 – 29.0 | |
| Acclim. = 10 - 15°C | 28.2 – 31.6 | |
| Acclim. = 15 - 20°C | 30.8 – 34.0 | |
| Acclim. = 20 - 25°C | 33.6 – 33.8 | |
| Acclim. = 25 - 30°C | 33.2 | 31.2 ¹ |
| Laboratory Lethal Studies – CTM | | |
| Acclim. = 5 - 10°C | 28.6 | |
| Acclim. = 10 - 15°C | 30.7 – 33.2 | |
| Acclim. = 15 - 20°C | 33.1 | |
| Acclim. = 20 - 25°C | 33.1 – 36.9 | |
| Acclim. = 25 - 30°C | 36.1 – 36.9 | 32.1 – 32.9 ² |
| Acclim. = 30 - 32°C | 40.4 | |
| Threshold from Colorado | | 31.9 |
| Recommended Acute Temperature Tolerance (MDMT) | | 32 |

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

²CTM values reduced by 2.0°C to estimate quasi-UILT values. Quasi-UILT values then reduced by 2°C to provide 100% survival (See *Methodology*)

A review of the laboratory studies suggests that an appropriate acute criterion should fall between 31.2 and 32.9°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 fathead minnow, EPA did not provide a recommended acute threshold. Based upon the available data, the recommended acute threshold for fathead minnow is 32°C. This value is consistent with the value established by the State of Colorado and within the range identified by the UILT and CTM studies.

References

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ATTACHMENT A

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

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Table A-1. 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 |
| Cherry et al. (1975) | <1 year | 12 - 27 | 19.8 – 28.9 | | 20.6 – 29.6 | Upper 95% confidence limits on averages | | |
| Jones and Irwin (1965) | Juvenile, adult | 4 - 30 | 8.8 – 22.6 | | <14 - <28 | Temperatures occupied about 80% of time | 23.4 | |
| Opuszynski (1971) | Juvenile, adult | 10 - 30 | 21.6 – 29.3 | | 23.4 – 31.1 | Upper preference limit – 1 standard deviation above average | | |

Table A-2. Chronic Temperature Tolerances – Laboratory Upper Temperature Avoidance Studies

| Reference | Age or Size | Acclim. Temp. (°C) | Temperature (°C) | Comment |
|----------------------|-------------|--------------------|------------------|---------|
| Cherry et al. (1975) | <1 year | 12 - 27 | 22 - 32 | |

Table A-3. Chronic Temperature Tolerances – Colorado

| Reference | Temperature (°C) | Comments |
|----------------------|------------------|---------------------------|
| Colorado WQCD (2007) | 28.8 | Recommended level as MWAT |

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ATTACHMENT B

Detailed Summary of Acute Thermal Tolerance Values for Fathead Minnow, 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 |
| Brett (1944) | Juvenile | 10 | 12-hour | 29.0 | Acclimation temperatures estimated from other information in paper | | |
| | | 14.5 | | 30.1 | | | |
| | | 15 | | 31.6 | | | |
| | | 17 | | 31.3 | | | |
| | | 17.5 | | 30.8 | | | |
| | | 20 | | 34 | | | |
| | | 21 | | 33.6 | | | |
| | | 22 | | 33.8 | | | |
| Hart and Dymond (1947) | Juvenile, adult | 10 | 22-hr | 28.2 | | | |
| | | 20 | 1.25-d | 31.7 | | | |
| | | 30 | 6.25-d | 33.2 | | | |
| Jensen (1972) | Adult | 6 | 12-hr | 26.1 - 27.1 | | | |

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

| Reference | Size or Age | Acclim. Temp. (°C) | Rate | Temperature (°C) | Endpoint |
|----------------------------------|-----------------|--------------------|-----------------------|------------------|---------------------|
| Carrier and Beitinger (1988) | Adult | 21 | 0.3°C/min (18°C/hour) | 34.8 | Loss of equilibrium |
| Carveth et al. (2006) | Adult | 25 | 0.3°C/min (18°C/hour) | 36.1 | Loss of equilibrium |
| | | | | 36.9 | Death |
| Castleberry and Cech, Jr. (1992) | Adult | 20 | 0.3°C/min (18°C/hour) | 33.1 | Loss of equilibrium |
| Pyron and Beitinger (1993) | Adult | 24 | 0.3°C/min (18°C/hour) | 36.2 – 36.9 | Loss of equilibrium |
| Richards and Beitinger (1995) | Adult | 5 | 0.3°C/min (18°C/hour) | 28.6 | Loss of equilibrium |
| | | 12 | | 30.7 | |
| | | 22 | | 36.4 | |
| | | 32 | | 40.4 | |
| Smale and Rabeni (1995) | Juvenile, adult | 26 | 2°C/hour | 36.5 | Loss of equilibrium |
| Spieler et al. (1977) | Juvenile, adult | 14.5 | 13°C/hour | 32.4 – 34.0 | Loss of equilibrium |
| Watenbaugh and Beitinger (1985) | Juvenile, adult | 21 | 0.3°C/min (18°C/hour) | 35.1 | Loss of equilibrium |

Table B-3. Acute Temperature Tolerances – Colorado

| Reference | Temperature (°C) | Comments |
|----------------------|-------------------------|-------------------------|
| Colorado WQCD (2007) | 31.9 | Recommended level as DM |

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