

Research Article

Water Temperature Manipulation During Walleye Egg Incubation Does Not Impact Egg Survival

Analuisa Larson, Van Calkins, Jill M. Voorhees, and Michael E. Barnes*

South Dakota Game, Fish and Parks, McNenny State Fish Hatchery, 19619 Trout Loop, Spearfish, SD 57783, USA

Abstract

Hatcheries incubating walleye (*Sander vitreus*) eggs may increase water temperatures later during egg development in an attempt to manipulate hatching time. This study examined the effect of one such increasing temperature scenario on egg survival and hatching time. Walleye eggs were subjected to one of two treatments: constant incubation temperature of 16°C until hatch (approximately two weeks), or an incubation temperature of 11°C for one week with an increase to 16°C until hatch. Mean (\pm SE) survival of eggs incubated in a constant temperature was 73.2% (\pm 0.2) and was not significantly different than the 66.8% (\pm 0.1) survival of walleye eggs subjected to the increased temperature treatment. Daily Temperature Units (DTU) to hatch were nearly identical and were also not significantly different. The results of this study indicate that the water temperature incubation regime was not harmful to the eggs and suggests that other temperature modification strategies may also not be injurious.

Introduction

Walleye (*Sander vitreus*) are a popular sport fish species belonging to the Percidae family. They have been introduced far beyond their native range of northern Canada to the southern United States [1-4]. Poor natural reproduction and overexploitation make stocking programs essential for maintaining walleye fisheries [5-7]. An estimated 1 billion walleye fry and juveniles are stocked annually in North

*Corresponding author: Michael E. Barnes, South Dakota Game, Fish and Parks, McNenny State Fish Hatchery, 19619 Trout Loop, Spearfish, SD 57783, USA; Tel: 1(605)-642-6920; E-mail: mike.barnes@state.sd.us

Citation: Larson A, Calkins V, Voorhees JM, Barnes ME (2026) Water Temperature Manipulation During Walleye Egg Incubation Does Not Impact Egg Survival. J Aquac Fisheries 10: 114.

Received: March 06, 2026; Accepted: March 17 2026; Published: March 23, 2026

Copyright: © 2026 Larson A, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

America, with additional production needed to meet angler demand [1,2,8,9].

The artificial spawning of wild or feral walleye broodstock begins the rearing process. Fertilized eggs are then typically hatchery-incubated, with the resulting fry either directly stocked or cultured further to a larger juvenile size prior to stocking [10]. Egg survival can be highly variable, making it important to understand the potential impacts of those variables which may be impacting walleye fry hatching rates [11,12].

Temperature is a vital factor in walleye egg growth and development [2,3]. Optimal incubation temperatures are between 9 and 15°C, with declining hatch rates and increasing development abnormalities at temperatures outside of this range [13]. In natural systems, successful recruitment is associated with steadily rising water temperatures, while highly variable temperatures may lead to weak recruitment [14,15]. Although walleye eggs are tolerant of some temperature fluctuations [15,16], it is not unusual for hatcheries to begin incubation at a lower temperature and gradually increase it during incubation. For example, Summerfelt and Johnson [17] described starting walleye egg incubation at 7°C and gradually increasing temperatures up to 15°C. Walleye egg hatching can be synchronized and accelerated by increasing incubating water temperature [18-20].

At Blue Dog State Fish Hatchery, Waubay, South Dakota, USA, well water at 10°C is used initially during walleye egg incubation. To prevent hatch issues associated with incubation at that temperature throughout the duration of incubation and to synchronize hatching times, the water temperature is increased up to 16°C towards the end of incubation. The effect of this temperature regime on walleye egg survival is unknown. Thus, the objective of this study was to examine the effects of increasing water temperature from 11°C to 16°C during walleye egg incubation on percent survival and the timing of hatching.

Methods

Wild walleye were collected from the Grand River, near Mobridge, South Dakota, USA and spawned on 5 May 2022. After fertilization, the eggs were pooled and transported approximately four hours to McNenny State Fish Hatchery in rural Spearfish, South Dakota, USA. Upon arrival, 20 eggs were randomly chosen and placed into a 9.5 cm diameter plastic Petri dishes containing 30 mL of well water (total hardness as CaCO₃ = 360 mg/L, alkalinity as CaCO₃ = 210 mg/L, pH = 7.6, total dissolved solids = 390 mg/L). This procedure was repeated for 10 Petri dishes (200 eggs total were used). Petri dish incubation techniques for walleyes are described by Voorhees and Barnes [21], with daily water exchanges. Dead eggs and hatched fry were counted and removed daily as well.

Two temperature regimes were used in this experiment. Five Petri dishes were incubated at 16°C, the other five dishes were incubated for the first seven days in a refrigeration unit at 11°C (Wine Enthusiasts Model 268 78 28 01, Valhalla, New York, USA) and then incubated at 16°C through hatch. Egg survival to fry hatch was calculated using the following formula:

$$\text{Survival (\%)} = 100 \times \frac{\text{Initial Egg Number} - \text{Number of Dead Eggs and Fry}}{\text{Initial Egg Number}}$$

Data were analyzed using t-tests and Levene's test with the SPSS (24.0) statistical analysis program (IBM, Armonk, New York, USA). Percentage data were log transformed prior to analysis to stabilize variances [22]. Significance was pre-determined at $p < 0.05$.

Results

Percent survival to hatch was not significantly different between the two incubation temperature treatments (Table 1). Mean (\pm SE) percent survival of the eggs incubated at a constant 11°C was 73.2% (± 0.2), compared to 66.8% (± 0.1) for the eggs where the incubation temperature was increased. Daily Temperature Units (DTU) to hatch was also not significantly different between the treatments. However, DTU to hatch was significantly more variable in the eggs where incubation temperatures increased to 16°C ($P = 0.005$).

Table 1: Mean \pm SE percent survival to hatch and daily temperature units (DTU) to hatch for walleye eggs incubated at different temperature treatments: an ambient temperature of 16°C throughout incubation, or at 11°C for the first seven days of incubation and then increased to 16°C until hatch ($n = 5$).

	Temperature Regime		P
	Constant 16°C	11°C increased to 16°C	
Survival (%)	73.2 \pm 0.2	66.8 \pm 0.1	0.33
Mean hatch (DTU)	155 \pm 1	157 \pm 4	0.74

Discussion

The results of this experiment indicate increasing walleye egg incubation temperature from 11°C to 16°C does not negatively impact survival to hatch. The temperature regime used in this study somewhat mimics that of natural systems, where rising temperatures are beneficial for successful walleye reproduction [14,15]. Summerfelt and Johnson [17] described using a similar incubation temperature protocol, increasing temperatures from 7°C at the start of walleye egg incubation to as high as 15°C just prior to hatch. Although Schneider et al. [15] did not increase temperatures during walleye egg incubation, they noted no negative effects on egg survival when temperatures fluctuated over the course of hatchery incubation. Short-term 4-hour temperature changes of 4.4°C during walleye egg incubation was also benign [23]. Lastly, even though the 16°C temperature used in this study was above the 15°C listed as optimal for walleye egg incubation by Koenst and Smith [13], it was not high enough to cause detrimental effects.

The approximately 70% egg survival-to-hatch observed in this study was typical of the 60% to 80% survival reported for production hatcheries [13,15,17,24,25]. However, it is higher than the 50% to 60% survival to hatch of walleye eggs from Lake Oahe, South Dakota over several previous years [26-31]. In contrast, Czesny et al. [10] reported survival to the eyed stage of development of walleye eggs at over 90% during a small-scale experiment.

The 155 daily temperature units until hatch observed in this study for both treatments were similar to that reported by [32,33,12,21]. However, McElman and Balon [34] reported a range from 101-to-169 DTU-to-hatch for walleye eggs incubated at a constant temperature of 15°C. Ney [35] also reported a range of DTU-to-hatch of 168 DTU at 8°C and 210 DTU at

15°C. A mean of 265 DTU-to-hatch was observed from a wild population of walleyes in Minnesota, USA [36]. Walleye egg hatching can occur over a few hours to several days [37] and is prolonged in cooler incubation temperatures [13,38].

Walleye egg hatching can be accelerated and synchronized by increasing incubating water temperature [18-20]. This study indicated that such temperature increases can occur later in incubation without negatively impacting survival. Temperature increases to synchronize hatch have also been used in other fish species [18-20].

In conclusion, because walleye egg survival-to-hatch and DTU-to-hatch are not affected by the increasing temperature regime used in this study, it is likely that similar temperature manipulations could be used by hatchery personnel to control the timing of hatching. In addition, walleye egg incubation temperatures could also likely be manipulated to synchronize hatching times.

Acknowledgement

We thank the walleye spawning crews in South Dakota for providing the eggs for this experiment.

References

1. Fenton R, Mathias JA, Moodie GEE (1996) Recent and future demand for walleye in North America. *Fisheries* 21: 6-12.
2. Halverson MA (2008) Stocking trends: A quantitative review of governmental fish stocking in the United States, 1931 to 2004. *Fisheries* 33: 69-75.
3. Feiner ZS, Hook TO (2015) Environmental biology of percid fishes. In: Patrick Kestemont, Konrad Dabrowski, Robert C. Summerfelt (eds.). *Biology and Culture of Percid Fishes: Principles and Practices*. Springer, Dordrecht 61-100.
4. Summerfelt RC, Clayton RD, Johnson JA, Kinnunen RE (2010) Production of walleye as potential food fish. North Central Regional Aquaculture Center, Fact Sheet Series 116.
5. Johnson FH (1961) Walleye egg survival during incubation on several types of bottom in Lake Winnibigoshish, Minnesota, and connecting waters. *Trans Am Fish Soc* 90: 312-322.
6. Sullivan MG (2003) Active management of walleye fisheries in Alberta: Dilemmas of managing recovering fisheries. *N Am J Fish Manag* 23: 1343-1358.
7. Shaw SL, Sass GG, van DeHey JA (2018) Maternal effects better predict walleye recruitment success in Escanaba Lake, Wisconsin, 1957-2015: implications for regulations. *Can J Fish Aquat Sci* 75: 2320-2331.
8. Kerr SJ (2008) A survey of walleye stocking activities in North America. Fish and Wildlife Branch, Ontario Ministry of Natural Resources, Peterborough, Ontario.
9. Kerr SJ (2011) Stocking and marking: Lessons learned over the past century. In: Bruce A. Barton, (ed.). *Biology, Management, and Culture of Walleye and Sauger*. American Fisheries Society, Bethesda, Maryland 423-449.
10. Czesny S, Rinchar J, Dabrowski K (2005) Intrapopulation variation in egg lipid and fatty acid composition and embryo viability in a naturally spawning walleye population from an inland reservoir. *N Am J Fish Manag* 25: 122-129.
11. Colby PJ, Nepszy SJ (1981) Variation among stocks of walleye (*Stizostedion vitreum vitreum*): management implications. *Can J Fish Aquat Sci* 38: 1814-1831.
12. Latif MA, Bodaly RA, Johnston TA, Fudge RJP (1999) Critical stage in developing walleye eggs. *N Am J Aquac* 61: 34-37.

13. Koenst WM, Smith LL Jr (1976) Thermal requirements of the early life history stages of walleye (*Stizostedion vitreum vitreum*) and sauger (*Stizostedion canadense*). *Can J Fish Aquat Sci* 33: 1130-1138.
14. Schneider JC (1997). Dynamics of a bluegill, walleye, and yellow perch community. Michigan Department of Natural Resources, Fisheries Research Report 2020.
15. Schneider JC, Copeland J, Wolgamood M (2002) Tolerance of incubating walleye eggs to temperature fluctuation. *N Am J Aquac* 64: 75-78.
16. Dabrowski K, Wojno M, Miller M, Kwasek K, Grayson J (2018) Continued embryonic development, survival, and growth of walleye larvae following exposure to dewatering and storage in melting-ice temperatures. *N Am J Aqua* 80: 404-410.
17. Summerfelt RC, Johnson JA (2015) Intensive culture of walleye from egg incubation to juvenile. In: Patrick Kestemont, Konrad Dabrowski, Robert C. Summerfelt (eds.). *Biology and Culture of Percid Fishes: Principles and Practices*. Springer, Dordrecht 313-335.
18. Kamler E, Keckeis H, Bauer-Nemeschkal E (1998) Temperature-induced changes of survival, development and yolk partitioning in *Chondrostoma nasus*. *J Fish Biol* 53: 658-682.
19. Kamiński R, Kamler E, Korwin-Kosakowski M, Myszkowski L, Wolnicki J (2006) Effects of different incubation temperatures on the yolk-feeding stage of *Eupallasella percnurus* (Pallas). *J Fish Biol* 68: 1077-1090.
20. Laurel BJ, Hurst TP, Copeman LA, Davis MW (2008) The role of temperature on the growth and survival of early and late hatching Pacific cod larvae (*Gadus macrocephalus*). *J Plankton Res* 30: 1051-1060.
21. Voorhees JM, Barnes ME (2024) Incubation of walleye eggs in petri dishes. *N Am J Aquac* 86: 260-264.
22. Warton DI, Hui FKC (2011) The arcsine is asinine: The analysis of proportions in ecology. *Ecology* 92: 3-10.
23. Allbaugh CA, Manz JV (1964) Preliminary study of the effects of temperature fluctuations on developing walleye eggs and fry. *N Am J Aquac* 26: 175-180.
24. Satterfield JR, Flickinger SA (1995) Factors influencing storage potential of preserved walleye semen. *N Am J Aquac* 57: 175-181.
25. Gonsorowski AC, Sweet BD, Voorhees JM, Barnes ME (2024) Survival of eggs spawned from large walleyes. *J Aquac Fish* 8: 086.
26. Wagers R, Broughton J, Moen C (1994) 1992 Blue Dog Lake Fish Hatchery Annual Production Report. Annual Report No. 94-13; South Dakota Department of Game, Fish and Parks: Pierre, South Dakota.
27. Wagers R, Broughton J, Moen C (1994) 1993 Blue Dog Lake Fish Hatchery Annual Production Report. Annual Report No. 94-19; South Dakota Department of Game, Fish and Parks: Pierre, South Dakota.
28. Wagers R, Broughton J, Moen C (1995) 1994 Blue Dog Lake Fish Hatchery Annual Production Report. Annual Report No. 95-12; South Dakota Department of Game, Fish and Parks: Pierre, South Dakota.
29. Wagers R, Broughton J, Moen C (1996) 1995 Blue Dog Lake Fish Hatchery Annual Production Report. Annual Report No. 96-17; South Dakota Department of Game, Fish and Parks: Pierre, South Dakota.
30. Wagers R, Broughton J, Moen C (1998) 1996 Blue Dog Lake Fish Hatchery Annual Production Report. Annual Report No. 98-1; South Dakota Department of Game, Fish and Parks: Pierre, South Dakota.
31. Broughton J, Smidt R, Ward M, Rasmus R, Holm E, et al. (2012) Blue Dog Lake State Fish Hatchery Annual Production Report. Annual Report No. 13-01; South Dakota Department of Game, Fish and Parks: Pierre, South Dakota.
32. Nelson WR, Hines NR, Beckman LG (1965) Artificial propagation of saugers and hybridization with walleyes. *N Am J Aquac* 27: 216-218.
33. Colesante RT, Youmans NB, Ziolkowski B (1986) Intensive culture of walleye using brine shrimp and formulated diets. *N Am J Aquac* 48: 33-37.
34. McElman JF, Balon EK (1979) Early ontogeny of walleye (*Stizostedion vitreum*) with steps of saltatory development. *Environ Biol Fishes* 4: 309-348.
35. Ney JJ (1978) A synoptic review of yellow perch and walleye biology. In: Robert L Kendall (ed.). *Selected Coolwater Fishes of North America*. American Fisheries Society, Special Publication 11, Bethesda, Maryland 1-12.
36. Malison JA, Held JA (1996) Reproductive biology and spawning. In: Robert C Summerfelt (ed.). *Walleye Culture Manual*. North Central Regional Aquaculture Culture Series 101, Iowa State University 101: 11-18.
37. Thompson D (1996) Stripping, fertilizing, and incubating walleye eggs at a Minnesota hatchery. In: Robert C Summerfelt (ed.). *Walleye Culture Manual*. North Central Regional Aquaculture Culture Series 101, Iowa State University 101: 41-44.
38. Colby PJ, Nicol RE, Ryder RA (1979) Synopsis of biological data on the walleye *Stizostedion v. vitreum* (Mitchill 1818), Fisheries Synopsis No. 119, Food and Agriculture Organizations of the United Nations.



- In Industrial Biotechnology | ISSN: 2639-5665
- Advances In Microbiology Research | ISSN: 2689-694X
- Archives Of Surgery And Surgical Education | ISSN: 2689-3126
- Archives Of Urology
- Archives Of Zoological Studies | ISSN: 2640-7779
- Current Trends Medical And Biological Engineering
- International Journal Of Case Reports And Therapeutic Studies | ISSN: 2689-310X
- Journal Of Addiction & Addictive Disorders | ISSN: 2578-7276
- Journal Of Agronomy & Agricultural Science | ISSN: 2689-8292
- Journal Of AIDS Clinical Research & STDs | ISSN: 2572-7370
- Journal Of Alcoholism Drug Abuse & Substance Dependence | ISSN: 2572-9594
- Journal Of Allergy Disorders & Therapy | ISSN: 2470-749X
- Journal Of Alternative Complementary & Integrative Medicine | ISSN: 2470-7562
- Journal Of Alzheimers & Neurodegenerative Diseases | ISSN: 2572-9608
- Journal Of Anesthesia & Clinical Care | ISSN: 2378-8879
- Journal Of Angiology & Vascular Surgery | ISSN: 2572-7397
- Journal Of Animal Research & Veterinary Science | ISSN: 2639-3751
- Journal Of Aquaculture & Fisheries | ISSN: 2576-5523
- Journal Of Atmospheric & Earth Sciences | ISSN: 2689-8780
- Journal Of Biotech Research & Biochemistry
- Journal Of Brain & Neuroscience Research
- Journal Of Cancer Biology & Treatment | ISSN: 2470-7546
- Journal Of Cardiology Study & Research | ISSN: 2640-768X
- Journal Of Cell Biology & Cell Metabolism | ISSN: 2381-1943
- Journal Of Clinical Dermatology & Therapy | ISSN: 2378-8771
- Journal Of Clinical Immunology & Immunotherapy | ISSN: 2378-8844
- Journal Of Clinical Studies & Medical Case Reports | ISSN: 2378-8801
- Journal Of Community Medicine & Public Health Care | ISSN: 2381-1978
- Journal Of Cytology & Tissue Biology | ISSN: 2378-9107
- Journal Of Dairy Research & Technology | ISSN: 2688-9315
- Journal Of Dentistry Oral Health & Cosmesis | ISSN: 2473-6783
- Journal Of Diabetes & Metabolic Disorders | ISSN: 2381-201X
- Journal Of Emergency Medicine Trauma & Surgical Care | ISSN: 2378-8798
- Journal Of Environmental Science Current Research | ISSN: 2643-5020
- Journal Of Food Science & Nutrition | ISSN: 2470-1076
- Journal Of Forensic Legal & Investigative Sciences | ISSN: 2473-733X
- Journal Of Gastroenterology & Hepatology Research | ISSN: 2574-2566
- Journal Of Genetics & Genomic Sciences | ISSN: 2574-2485
- Journal Of Gerontology & Geriatric Medicine | ISSN: 2381-8662
- Journal Of Hematology Blood Transfusion & Disorders | ISSN: 2572-2999
- Journal Of Hospice & Palliative Medical Care
- Journal Of Human Endocrinology | ISSN: 2572-9640
- Journal Of Infectious & Non Infectious Diseases | ISSN: 2381-8654
- Journal Of Internal Medicine & Primary Healthcare | ISSN: 2574-2493
- Journal Of Light & Laser Current Trends
- Journal Of Medicine Study & Research | ISSN: 2639-5657
- Journal Of Modern Chemical Sciences
- Journal Of Nanotechnology Nanomedicine & Nanobiotechnology | ISSN: 2381-2044
- Journal Of Neonatology & Clinical Pediatrics | ISSN: 2378-878X
- Journal Of Nephrology & Renal Therapy | ISSN: 2473-7313
- Journal Of Non Invasive Vascular Investigation | ISSN: 2572-7400
- Journal Of Nuclear Medicine Radiology & Radiation Therapy | ISSN: 2572-7419
- Journal Of Obesity & Weight Loss | ISSN: 2473-7372
- Journal Of Ophthalmology & Clinical Research | ISSN: 2378-8887
- Journal Of Orthopedic Research & Physiotherapy | ISSN: 2381-2052
- Journal Of Otolaryngology Head & Neck Surgery | ISSN: 2573-010X
- Journal Of Pathology Clinical & Medical Research
- Journal Of Pharmacology Pharmaceutics & Pharmacovigilance | ISSN: 2639-5649
- Journal Of Physical Medicine Rehabilitation & Disabilities | ISSN: 2381-8670
- Journal Of Plant Science Current Research | ISSN: 2639-3743
- Journal Of Practical & Professional Nursing | ISSN: 2639-5681
- Journal Of Protein Research & Bioinformatics
- Journal Of Psychiatry Depression & Anxiety | ISSN: 2573-0150
- Journal Of Pulmonary Medicine & Respiratory Research | ISSN: 2573-0177
- Journal Of Reproductive Medicine Gynaecology & Obstetrics | ISSN: 2574-2574
- Journal Of Stem Cells Research Development & Therapy | ISSN: 2381-2060
- Journal Of Surgery Current Trends & Innovations | ISSN: 2578-7284
- Journal Of Toxicology Current Research | ISSN: 2639-3735
- Journal Of Translational Science And Research
- Journal Of Vaccines Research & Vaccination | ISSN: 2573-0193
- Journal Of Virology & Antivirals
- Sports Medicine And Injury Care Journal | ISSN: 2689-8829
- Trends In Anatomy & Physiology | ISSN: 2640-7752

Submit Your Manuscript: <https://www.heraldopenaccess.us/submit-manuscript>