Thermal Tolerances and Physiological/Behavioral Responses of Hard Clams

Investigator: Shirley Baker, University of Florida (UF)/IFAS SFFGS Fisheries and Aquatic Sciences Program

Purpose: This study investigates the physiological responses of hard clams (*Mercenaria mercenaria*) to elevated summer temperatures, with a focus on oxygen uptake, behavioral stress indicators, and mortality. By examining how metabolism and chronic heat exposure intersect to challenge clam survival, this work aimed to inform research priorities, guide selective breeding efforts, and support the development of practical management strategies for shellfish aquaculture in a warming climate.

Results: To assess the impacts of elevated summer temperatures on hard clam physiology and survival, we conducted controlled laboratory experiments exposing clams to sustained temperatures. We monitored oxygen uptake rates across a temperature gradient to identify thermal performance limits and observed behavioral responses such as siphon extension and gaping as indicators of stress. Cumulative mortality was tracked over an 18-day period to assess delayed lethal effects. These measurements were used together to evaluate how chronic heat exposure influences metabolic function, behavior, and survival in cultured clams.

Our trials indicated that sustained exposure to elevated temperatures – particularly 34°C (93°F) – induced significant physiological stress in hard clams. While no immediate mortality was observed, cumulative mortality increased over time, reaching over 20% by Day 18. This delayed pattern highlights the chronic impact of sublethal heat exposure, even in the absence of acute lethal effects.

Oxygen uptake data revealed that clam metabolism peaks near 31°C (88°F), with notable individual variability at this temperature. Some clams maintained high oxygen uptake, while others showed a marked decline, suggesting that this temperature represents a physiological tipping point. Beyond 31°C, oxygen uptake decreased, consistent with metabolic breakdown and reduced aerobic capacity.

Behavioral observations further supported the onset of thermal stress. At 34°C (93°F), more than 50% of clams exhibited abnormal behaviors including gaping, extended siphons, and slow responsiveness to stimuli. These responses not only signal internal stress but may also increase vulnerability to predation and disease. When paired with metabolic data, behavioral changes serve as early indicators of impending mortality.

Together, these results suggest that 34°C (93°F) exceeds the thermal optimum for hard clams and that prolonged exposure leads to progressive declines in function and survival. This threshold may help inform site selection, seasonal timing, and the development of thermally resilient clam lines.

Relevance: Rising summer water temperatures in the Gulf pose increasing challenges for hard clam aquaculture. Understanding how clams respond to prolonged heat stress is critical for maintaining productivity and guiding adaptive management.

Response: We exposed clams to sustained high temperatures and monitored metabolic rate, behavioral stress indicators, and cumulative mortality. This approach allowed us to assess both immediate and delayed physiological responses to thermal stress.

Results: Clams showed peak oxygen uptake around 31°C (88°F), followed by a decline at 34°C 93°F), indicating metabolic stress. Behavioral signs such as gaping and sluggish responses became widespread at 34°C (93°F), and cumulative mortality exceeded 20% after 18 days of exposure at 34°C (93°F).

Recap: These findings suggest that 34°C (93°F) exceeds the thermal tolerance threshold for hard clams. Metabolic disruption, abnormal behavior, and mortality point to the need for proactive management strategies.