

Cold Tolerance in Red Drum

Introduction

Red drum *Sciaenops ocellatus* is an important ecological, seafood, and recreational-fishery resource. Their natural range extends from the United States mid-Atlantic coast, throughout the Gulf of Mexico, and the Caribbean Sea.

Production of red drum in culture is limited by the species' low tolerance to cold temperature (Sailliant et al., 2008). Red drum have high mortality rates during sudden or severe cold weather where water temperature can decline by up to 32 degrees Fahrenheit in a few hours. This causes a decline in red drum population, which in turn could cause anglers to catch less fish.

Purpose

This research brief describes cold tolerance in red drum population. With this information, researchers can build effective cold tolerant red drum breeding programs that could increase and maintain red drum population.

Testing Cold Tolerance

There are a few different ways to test cold tolerance in red drum. In one study that was attempting to determine the genetic effect of cold tolerance in red drum, researchers acclimated the fish to 75 degrees Fahrenheit then directly transferred them from the tank in which they were acclimated to a tank in which the water was 42 degrees Fahrenheit (Saillant et al., 2007). The direct transfer was too fast and the fish died quickly from the shock because they were not able to gradually adjust to the water temperature change. The study concluded that further assessment of the heritability of tolerance to the stress induced by progressively decreasing temperatures and the correlation with cold tolerance should be done, instead of quickly decreasing temperatures, in order to design selective breeding strategies to improve cold tolerance in red drum.

In a heritability of cold tolerance in red drum study done in 2007, fish were put in three tanks in which the water temperature in the tanks was controlled by three chiller units. Fish were acclimated to 77 degrees Fahrenheit then the water in each tank was reduced by 1 degree Celsius per day until it reached 53.6 degrees Fahrenheit. The water temperature was reduced 1 degree Celsius every two days until the water temperature reached 37.4 degrees Fahrenheit and stayed at that temperature until all of the fish died. This study was more accurate because the fish were able to slowly adjust to the decreasing temperature instead of sudden temperature change similar to that in the first study.

Figure 1 shows the mortality results from this study. The first fish died when the temperature reached 41 degrees Fahrenheit. Because most of the mortality in the study occurred when the temperature had reached a low threshold of about 38 degrees Fahrenheit, cold tolerance in Red drum was quantified.

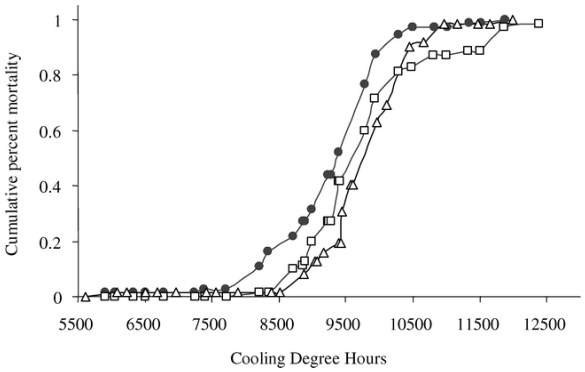

Figure 1. Cumulative mortality (%) of juvenile red drum held in tanks during a cold tolerance challenge in 2004. Temperature was decreased gradually from 77ºF to 37ºF over 30-day period. Survival time is expressed in cooling-degree-hours. Symbols denote individual replicate tanks (70 fish/tank).

In the heritability of cold tolerance in red drum study, cold tolerance of the individual fish was measured by survival time and a cooling-degree-hours index. Most of the mortality in this study occurred when the temperature reached about 38 degrees Fahrenheit. This study constituted the first report of cold tolerance heredity in red drum and demonstrated the occurrence of significant genetic effects on cold tolerance in red drum juveniles (Ma et al., 2007).

This information could be used by conservationists to determine red drum's mortality rate in times when the weather gets progressively colder or when sudden cold fronts move through the region. In January 1973, researchers at the University of Texas Marine Science Institute noted that after a cold front, water temperatures on shallow flats were near 33 degrees Fahrenheit (Holt & Holt, 1983). They estimated that in Texas waters due to cold fronts water temperatures could fall from 5 to 15 degrees Celsius in a matter of hours. Using the information researchers have now, they could estimate the temperature in which most red drum died.

Effects of Temperature

Other studies focused on the hypothesis that the growth of red drum exposed to low temperatures can be limited by their metabolic capacity to exploit available food energy. Under laboratory conditions, researchers evaluated the growth and marginal metabolic scope (MMS) of juvenile red drum exposed to two levels of dietary energy, high levels and low levels, and to three temperatures; 19, 25, and 29 degrees Celsius, for a period of six weeks (Fontaine et al., 2007). The red drum exposed to low temperatures exhibited low growth rates and a decrease in capacity for metabolic performance. Low temperature also reduced metabolic capacity as measured by MMS, but there was no significant effect of feed energy density on metabolic capacity. Therefore, feed energy did not limit metabolism in the same way that it limited growth. Researchers could use this information to understand the growth rates of red drum by determining the temperature and food availability in red drum's natural ranges. If red drum growth rates could be controlled, fishermen could catch bigger fish.

In another study, researchers studied wild adult red drum for one year to evaluate seasonal changes in body composition in comparison with cultured red drum (Craig, MacKenzie, Jones, & Gatlin, 2000). They found that in relatively warm water temperature from April to October, red drum exhibited higher metabolic rates and higher feeding rates. The cultured fish and the wild fish had similar muscle protein and lipid composition. Although the wild red drum diet was unknown compared to the diet of the cultured red drum, in the end, the body composition between the wild and cultured red drum was quite similar. This means that more than likely red drum are similar in most of their natural habitats, regardless of

what they are foraging on their body compositions are alike.

Discussion

Potential genetic improvement of cold tolerance in red drum would be valuable in order to maintain and increase their population. If red drum could be conditioned to build up a tolerance to the cold then the population would increase which in turn would lead to an increase in catches for fisherman. Further evaluation of heritability of cold tolerance is needed in order to design effective selective breeding strategies to improve cold tolerance in cultured red drum (Saillant, et al., 2007). All of the studies discussed above are valuable in understanding red drum behavior, adaptability, and growth rates. With this understanding, researchers can then begin breeding programs. Ecological tolerance in red drum may evolve when environments vary rapidly (Ruehl & DeWitt, 2007). Researchers should study red drum in northern waters such as in the Atlantic coast, and determine if red drum populations there exhibit greater cold tolerance than red drum populations in the Caribbean or the Gulf Coast. If the red drum do exhibit greater cold tolerance then researchers could use them to improve stocking programs.

Conclusion

Studies have shown that with time and a breeding program, cold tolerance for red drums is possible. In studying their natural habitat and food availability, researchers can determine red drum growth rates which will contribute to conserving and maintaining red drum populations.

Audience

This research is intended for research and scientific purposes, but may be adapted for analysis by conservationists who want to maintain red drum populations. This research could be used by other researchers and scientists to improve or design an effective breeding strategy for cold tolerance in red drum.

References

Craig, S. R., MacKenzie, D. S., Jones, G., & Gatlin III, D. M., (2000). Seasonal changes in the reproductive condition and body composition of free-ranging red drum. Sciaenops ocellatus. *Aquaculture, 190*(1-2), 89.

Fontaine, L. P., Whiteman K. W., Li, P., Burr G. S., Webb K. A., Goff, J., et al. (2007). Effects of temperature juvenile red drum. *Transactions of the American Fisheries Society, 136*(5), 1193-1205.

Holt, S.A., & Holt, J.G. (1983). Cold Death of Fishes at Port Aransas, Texas. *The Southwestern Naturalist, 28*(4), 464-466.

Ma, L., Saillant, E., Gatlin III, D.M., Neill W. H., Vega R. R., & Gold J. R. (2007). Heritability of cold tolerance in red drum. *North American Journal of Aquaculture, 69*(4), 381-387.

Saillant, E., Wang, X., Liang, M., Gatlin III, D. M., Vega, R. R., & Gold, J. R. (2008). Genetic effects on tolerance of acute stress in red drum, Scaianeops ocellatus L., *Aquaculture Research, 39*(14), 1393-1398.

Ruehl, C. B., & DeWitt, T. J. (2007). Trophic plasticity and foraging performance in red drum. Scianops ocellatus (Linnaeus). *Journal of Experimental Marine Biology and Ecology, 349*(2), 284.