

Temperature Dependent Sex Determination in Southern Flounder From the Texas Gulf Coast and Implications of Climate Change

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Abstract

In marine flatfish of the genus *Paralichthys*, changes in temperature play a role in sex determination. Global climate change may have significant effects on southern flounder (*Paralichthys lethostigma*), a commercially and recreationally important flatfish whose populations have steadily declined in Texas in the last 25 years.

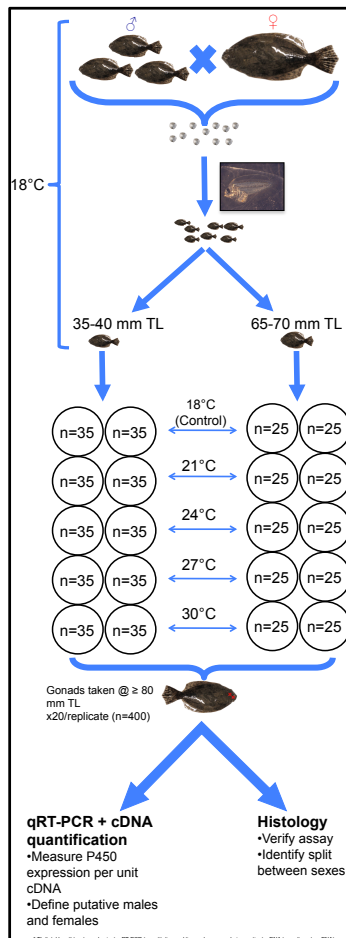
Introduction

Temperature can play a major role in the rate of development of marine teleosts. The threat of physiological impairment has been increased as global temperatures have changed at a more rapid rate than is shown by historical records. Two of the areas most susceptible to global climate change are shallow water environments, particularly estuaries, and coral reefs. The temperature sensitive enzyme complex responsible for estrogen biosynthesis in vertebrates is aromatase cytochrome P450 (P450) and is a critical component in ovarian differentiation (Luckenbach et al., 2005). The critical period where sex is influenced by temperature has not yet clearly been defined in southern flounder. Research on southern flounder from North Carolina waters has shown that sex determination is temperature dependent with temperatures of 18°C or below and 28°C or above producing male skewed sex ratios and temperature of 23°C producing a near 1:1 male to female ratio. This leaves a narrow temperature threshold for 50/50 sex ratios (Luckenbach et al., 2003). This is significant because females attain much larger sizes than males. This work identifies some of the differences and similarities between mid Atlantic and Gulf of Mexico populations of southern flounder and highlights the potential effects of global climate change on a commercially and recreationally important marine flatfish. This will not only raise awareness, but it may help develop new management strategies to combat overfishing and the threat of global climate change. Identifying the timing of sexual differentiation and key temperatures for producing males and females in captivity can help fisheries management agencies produce the correct number of each sex for restocking as well as indicate at what size and age juveniles need to be stocked into the wild.

Objectives

- Investigate the effects of temperature on sex determination in southern flounder from Texas
- Further define the critical period of temperature influence on sex determination in southern flounder from Texas
- Identify differences between populations of southern flounder from North Carolina and Texas in terms of sex determination

Methods



Results

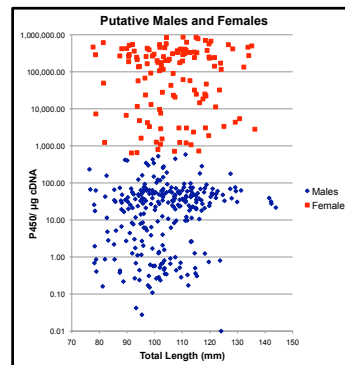


Figure 1a (Above). Putative males and females plotted by final total length and copies of P450 per µg cDNA. The Y-axis has been modified to a logarithmic scale to include all samples.

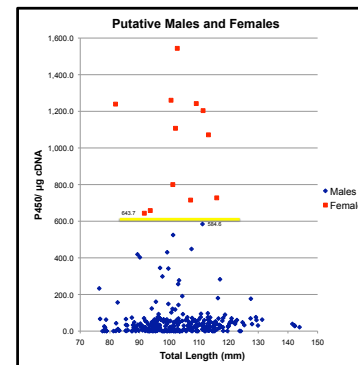


Figure 1b (Above). Putative males and females plotted by final total length and copies of P450 per µg cDNA. The Y-axis has been reduced to clearly show the separation between putative males and females by P450 µg cDNA expression. The lowest measured level in a female was 643.7 and the highest level measured in a male was 584.6. The yellow line illustrates the separation between sexes.

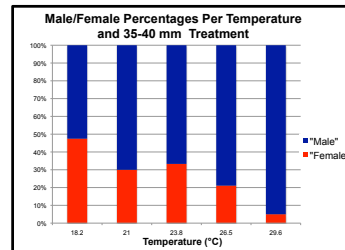


Figure 2a (Above). Effects of temperature and size on sex determination in juvenile southern flounder from Texas. Mean percentages of males and females produced from replicates of size group 1 (35-40 mm TL) at temperatures of 18.2, 21.0, 23.8, 26.5, and 29.6 °C.

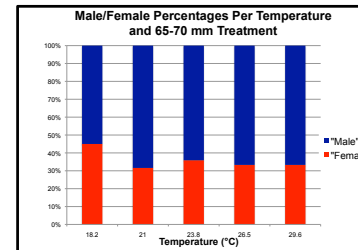


Figure 2b (Above). Effects of temperature and size on sex determination in juvenile southern flounder from Texas. Mean percentages of males and females produced from replicates of size group 2 (65-70 mm TL) at temperatures of 18.2, 21.0, 23.8, 26.5, and 29.6 °C.

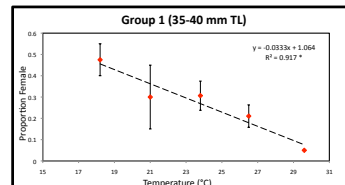


Figure 3a (Above). Linear regression of the effects of temperature and size on sex determination in juvenile southern flounder from Texas. The proportion of females produced by size group 1 (35-40 mm TL) at temperatures of 18.2°, 21.0°, 23.8°, 26.5°, and 29.6 °C.

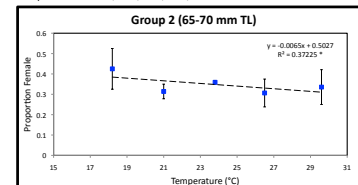


Figure 3b (Above). Linear regression of the effects of temperature and size on sex determination in juvenile southern flounder from Texas. The proportion of females produced by size group 2 (65-70 mm TL) at temperatures of 18.2°, 21.0°, 23.8°, 26.5°, and 29.6 °C.

Conclusions

- When comparing both groups, there is a significant difference in the proportion of females across these temperatures depending on size of exposure.
- The size range at which the sex of juvenile southern flounder is most influenced by temperature occurs between 35-65 mm TL.
- Increases in temperature from 18°C during this size range produce increasingly male skewed sex ratios in southern flounder from Texas.
- Temperatures producing near 1:1 sex ratios for southern flounder from North Carolina (23°C) differ from Texas (18°C).

Implications of Climate Change

We have seen increased temperatures in the last decade for South Texas (TCOON, 2000-2010). The Intergovernmental Panel for Climate Change (IPCC), Synthesis Report for 2007, predicts a 2-3 degree increase in climate for North America for the next 50 to 100 years. An increase in temperature may also lead to a shift in the starting point and duration of the winter spawning period of southern flounder. If the spawning period is delayed, juvenile southern flounder may enter the bays and estuaries later in the year. This exposure to warmer spring temperatures during sex determination could cause a shift in naturally occurring sex ratios and potentially reduce the number of new female recruits to future populations. The trend of fewer females with increased temperature seen in southern flounder from both North Carolina and Texas suggests that climate change may have negative effects on already threatened populations of southern flounder. With the sustainability of wild southern flounder populations already in question, this study calls attention to the urgency of improved management strategies to protect and ensure southern flounder for the future.

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