THE EFFECTS OF ENVIRONMENTAL HEAT STRESS ON HEAT SHOCK mRNA AND PROTEIN EXPRESSION IN MIRAMICHI ATLANTIC SALMON (*SALMO SALAR*) PARR †

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EXTENDED ABSTRACT ONLY- DO NOT CITE

The Atlantic salmon (*Salmo salar*) are one of Canada's most important recreational fish, and are now classified as an endangered species in parts of Canada and the United States. Reasons for the observed population declines are believed to be many, and include variables such as overfishing, pollution, habitat degradation and temperature stress. Water temperature is known to be one of the most important environmental variables affecting fish. High stream temperatures between 23°C and 25°C have been observed to cause mortality in trout populations (Bjornn and Reiser 1991). Although Atlantic salmon can tolerate slightly higher temperatures, 27-28°C, depending on their life stage (Garside 1973), the sub-lethal impacts of temperature on molecular and physiological processes within the various life history stages of Atlantic salmon are less understood. Previous studies have shown that behavioural changes in Atlantic salmon start to occur at temperatures well below their lethal maximum, in the range of 22-24°C, when they start searching for refuge (Cunjak et al. 1993). While these behavioural changes are helpful in determining stressful temperatures for fish, changes at the molecular level may be the first "early warning signals" of sub-lethal heat stress that will later be manifested at an organismal or population level.

One of the most common molecular indicators, or biomarkers, of temperature stress in all organisms is the heat shock response. This response is characterised by a dramatic change in the pattern of gene expression resulting in a rapid induction of heat shock mRNA and protein translation, and simultaneous repression of synthesis of other cellular proteins (Lindquist 1986). Despite the fact that many North American fish populations may currently be affected by warm temperatures in their aquatic ecosystems, few studies have examined both the thermal behaviour of these systems and the biological impacts of warm temperatures on resident species. The goal of the present study was therefore to further examine this issue on one of Canada's most important Atlantic salmon river systems, the Miramichi. This study combines laboratory experiments with temperature monitoring and fish sampling in the wild to determine whether Atlantic salmon parr from the Miramichi River in New Brunswick are currently experiencing significant sub-lethal heat stress during the warm summer months.

Experiments done on wild Atlantic salmon parr under controlled laboratory conditions indicated that Hsp 70 mRNA and protein and Hsp 30 mRNA were all significantly induced between 22 and 25ºC. Field sampling was done within two different Miramichi rivers, Catamaran Brook and the Little Southwest Miramichi River, chosen to reflect the range of thermal characteristics observed within the Miramichi River basin. Salmon parr were sampled from both of these rivers during moderate spring temperatures and a high temperature event in summer. This field data further indicated that the threshold for mRNA induction of both Hsp 70 and 30 is around 23ºC, but Hsp 70 protein levels were only significantly elevated in the field at 27ºC, a temperature that was observed in the more wide and shallow Little Southwest. Hsc 70 mRNA and protein levels were not significantly increased during heat stress under laboratory conditions. In the field, however, Hsc 70 mRNA was significantly increased at 23ºC and both Hsc 70 mRNA and protein levels were elevated at 27ºC.

Analysis of temperature data collected in the present study indicates that Atlantic salmon in the Miramichi River system may have to cope with water temperatures that frequently exceed 23ºC. Records showed that water temperatures in the Little Southwest exceeded 23ºC for an average of 29 days each summer over the past ten years. Since denaturation and aggregation of proteins is believed to be the primary signal for hsp mRNA induction, our combined results can be viewed as strong evidence that Miramichi River Atlantic salmon parr are probably experiencing significant protein damage in the wild for a significant portion of the summer. This issue clearly warrants further investigation since induction of a heat shock response has been shown to suppress the synthesis of other proteins (Parsell and Lindquist 1993).

In summary, the combination of heat shock mRNA and protein induction profiles obtained from both laboratory experiments and field sampling, as well as river temperature records, in the present study clearly show that Miramichi Atlantic salmon parr are commonly exposed to significant heat stress during the summer months. These results provide further evidence that the hsp response does commonly occur in some wild populations. Although this hsp response is an important adaptation contributing to the survival of organisms under extreme environmental conditions, it can also be viewed as an "early warning" that a given population may be experiencing significant sub-lethal thermal stress. In this regard, our findings also suggest that any further increases in water temperatures as a result of climate change could have profound consequences for one of Canada's most productive Atlantic salmon rivers.

References

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