

Science Project: Anthropogenic influences on the temperature regime in a chalk river

Summary SC040025

This report, produced in collaboration with English Nature and the Wessex Salmon and Rivers Trust, presents the findings of a preliminary exploration into changing temperature conditions in the River Avon. The report was commissioned following indications that reduced numbers of Atlantic salmon during hot, dry summers may be linked to high river temperatures. Using existing data sets, literature sources and dedicated water temperature measurements, the study makes a preliminary assessment of the Avon estuary's summer temperature regime, and explores the likely influence of various human activities on water temperature. It concludes that, of those activities investigated, the greatest impact on river temperature almost certainly stems from the historic removal of tree cover. The report provides some preliminary management recommendations and highlights a number of areas for further investigation.

Main findings

The Atlantic salmon is a cold-water species whose native range is largely determined by water temperature. In this study, a review of the literature, including a 2004 study of the Avon estuary, reveals that normal development of fertilised eggs is extremely temperature-sensitive, while upstream migration rarely occurs where maximum water temperatures exceed 20 to 22°C. In the Avon itself, the relative number of migrating fish that immediately enter the river is reported to decrease dramatically in response to reduced water flow and concomitant increases in water temperature. At the same time, with survival rates closely linked to promptness of entry into the river, more than half of returning stock have been

lost in recent hot, dry summers. This has led to increasing concerns that the salmon is now close to the extreme of its thermal tolerance range in the Avon and other rivers in southern England.

In addition to factors such as the temperature of water entering the river system (as rainfall, run-off or spring flow), and the changes that occur in-channel due to friction, evaporation and condensation, river temperature regimes may be significantly affected by other – largely anthropogenic – activities. With a view to better understanding how to manage England's southern rivers to avoid future losses of salmon stocks, this study examines the current impact of a number of these activities.

The report concludes that of all anthropogenic activities investigated – from climate change and historical changes in land-use, to modern water abstraction, fish farming, sewage effluent flows, weed cutting and water-meadow operation – removal of woodland has had the most significant impact on water temperatures to date. Dating back to prehistoric times the valleys of the River Avon and its tributaries have been heavily managed, dramatically altering the landscape from natural forest of oak, elm, lime, ash, field maple, hazel and alder, to one which is managed solely for agriculture, urban development and transport. Resulting changes in evapo-transpiration, run-off and groundwater recharge have affected stream flow, while modifications to the channel and the surrounding vegetation have significantly influenced the extent of warming and cooling by radiation, conduction and evaporation. Resulting temperature increases are estimated in the region of 5 to 8°C.



Estimated impacts of contemporary human activities on water temperature range from operating water meadows (inducing a maximum increase of 1-2°C) to sewage effluent discharge (inducing an increase in the order of only 0.12°C). Fish farms and water abstractions are also reported to lead to some increases in temperature, while continued climate change is expected to exacerbate any of these effects. However, the preliminary nature of these findings is emphasised and a series of further studies are recommended. These include expanding data gathering to upstream areas, where most of the temperature increases appear to take place.

Implications and recommendations

Given the observed effects of high water temperatures on both salmon development and salmon survival, together with growing concerns about salmon numbers in England's more southern rivers, improved river management could prove critical – both to salmon stocks and to other threatened species. Only by developing better understanding of the effects of current management activities on water volumes and temperatures can existing management tools and/or decision-making guidance be improved. With this in mind, this report makes a series of recommendations for both remedial action and future research:

remedial action

- careful tree planting – this could reduce levels of solar radiation reaching the water surface. However, the impact of any major reduction in solar radiation would need to be considered – particularly in light of current conservation and fisheries interests;

future research

- improvements in methodology for future studies – these should include monitoring upstream, better monitoring around water meadows and more attention to ambient meteorological conditions;
- a comprehensive review of the literature on the thermal biology of salmon – this should pay particular attention to climate change;
- longer-term assessment of the Avon system as input to assessing the effects of climate change on aquatic habitats in England and Wales;
- detailed experimental investigations into the effects of a) surface/emergent aquatic weed cover, and its removal, and b) water meadow flooding;
- verification of assumptions used in assessing the effects of water abstractions and more detailed temperature logging in the lower and, additionally, the upper reaches of the river.

This Summary relates to information from Science Project SC040025 reported in detail in the following output:-

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