# TURNING UP THE HEAT – Research project investigates water temperature effects on freshwater systems


All photographs Helen Dallas

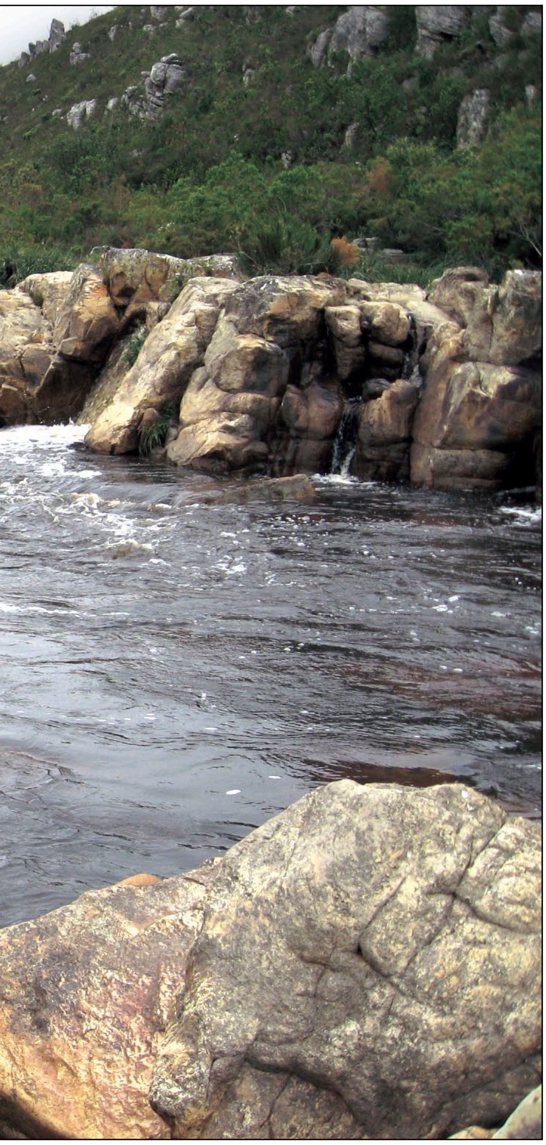
*A four-year-study, funded by the Water Research Commission (WRC) is investigating water temperature in rivers and biotic response. Article by Sue Matthews.*

Climate change is likely to have a range of impacts on South Africa's freshwater resources, causing a ripple effect of socio-economic consequences and putting the country's already stressed systems under increasing strain.

These impacts were explored during a two-day workshop held in the Western Cape in September 2008 and attended by more than 25 specialists. The workshop – jointly funded by the WRC and WWF – was convened by Helen Dallas of the Freshwater Consulting Group and Dr Nick Rivers-Moore (previously of) Ezemvelo KZN Wildlife.

The main repercussion of climate change worldwide is anticipated to be increased air temperatures and shifts in rainfall patterns. In South Africa, higher air temperatures are predicted for the entire country, while rainfall is expected to increase in the east and decrease in the west. The combination of rising air temperatures and lower rainfall in some regions will in all likelihood result in elevated water temperatures in riverine ecosystems, as one of the many side-effects of climate change.

The key point to emerge from the workshop, however, was that climate change is an additional, amplifying driver of system variability, and should not be viewed in isolation. Indeed, a paper published by Dr Dallas in ***Water SA*** identifies a number of other anthropogenic factors that affect water temperature in riverine ecosystems, such as thermal discharges from industrial plants, flow modification due to river impoundment,



inter-basin water transfers, and modification to riparian vegetation, which provides shade from direct solar radiation.

In addition, a variety of natural factors influence riverine water temperature. Obvious examples include regional factors like latitude and altitude, and climatic factors such as air temperature, cloud cover, wind speed and precipitation. But there are also hydrological influences such as the source of water, rate of flow and water volume, and structural influences such as topography and channel morphology, water depth and percentage of pool habitat. Plus, of course, there's spatial and temporal variation, as headwaters of a river system are typically cooler than lowland areas, and temperatures fluctuate according to the time of day and season.

While thermal characteristics of river systems - and the implications for aquatic organisms - have been relatively well studied in the northern hemisphere, information is sorely lacking for the southern hemisphere. In South Africa, particularly, water temperature data are largely confined to spot measurements and monthly trends, which are of limited use in understanding temperature effects on riverine biota.

Clearly, there is a need for fundamental research on water temperature and biotic response in South African systems, not only to understand and predict the impacts of climate change, but also to incorporate water temperature guidelines into the Ecological Reserve. To address this need, Dallas and Rivers-Moore are leading a four-year, WRC-funded research project that also involves the Albany Museum and Institute of Water Research in Grahamstown as collaborating organisations.

The project will allow Dallas – a research associate of UCT's Freshwater Research Unit - to combine her two main areas of expertise, given that she has considerable experience with SASS and other bioassessment tools, and previously co-authored and updated a review of the effect of water quality variables on aquatic ecosystems (WRC Report No: **TT 61/93** and **TT 224/04**).

"I've always been interested in how the physical and chemical aspects of water quality link to biology," she says. "Temperature and dissolved oxygen are two of the key variables that influence what lives where and how it survives. And we know that higher temperatures reduce the solubility of dissolved oxygen in water, decreasing its concentration and hence its availability to aquatic organisms."

The project's first aim is therefore to collect baseline water temperature data,

*Project leader Dr Helen Dallas is well known for her work on water quality and the SASS biomonitoring tool. Here she conducts a river health assessment in Tanzania, while Masai children look on.*

using loggers that measure temperature on an hourly basis. This ensures that detail is obtained on diurnal variation and temperature extremes, which are likely to be more ecologically significant than average temperatures.

"We've installed loggers at 92 sites on 62 rivers and streams in the Eastern,

*Loggers recording air temperature and relative humidity have been installed at some of the study sites to determine their relationship to water temperature.*

*The water temperature loggers are housed in a protective metal casing and positioned in a run in the thalwag – the point of deepest flow.*

Southern and Western Cape, and did the first download in May," says Dallas. "We've also had great collaboration with other research projects, allowing additional data to be sourced from a further 64 sites on 23 rivers."

Once a year's worth of baseline data have been collected, Dr Rivers-Moore will put his speciality to good use in developing a water temperature model to simulate daily minimum, maximum and mean water temperatures. The model will subsequently be refined and verified using the second year's data. At the same time, desktop analyses and laboratory studies will be conducted to understand the effect of temperature modifiers such as turbidity and flow so that these can be incorporated into the model, allowing water temperature time-series to be simulated under a range of different scenarios. Air temperatures are also being recorded at 45 of the study sites, with the ultimate goal of being able to predict water temperature from ambient air temperature.

Getting a handle on the factors that influence water temperature is only one aspect of the project though – the primary focus is to understand how water temperature regimes affect riverine biota. A number of studies are being conducted to achieve this, some undertaken by postgraduate students as MSc projects. One such project is investigating the thermal tolerance of aquatic macroinvertebrates through laboratory experiments. Typically, thermal tolerance studies assess lethal limits in terms of the minimum and maximum temperatures that animals can survive, sublethal effects such as physiological effects and disruption of reproduction and development, as well as behavioural avoidance preferences.

"Our research will initially focus on lethal limits, which should provide good fundamental data on the thermal tolerances of aquatic invertebrates, although there's still a long way to go," says Dallas. "It would be very useful to expand the research to include sublethal effects - such as the effect of temperature on growth, fecundity and fish spawning – and, of course, to develop some experiments to monitor behavioural responses."

Some indication of the effect of temperature on the developmental stages of aquatic insects will also be obtained through field studies on life history traits, such as the number of generations per year and emergence cues for particular species. Seasonal changes in temperature, together with photoperiod

*Dr Nick Rivers-Moore*

and dissolved oxygen in some cases, are known to affect the timing and duration of emergence, but little information is available for aquatic insects in local rivers. The research will involve monthly sampling of selected species with simultaneous data collection on water temperature, which will be linked to the rivers' hydrological aspects.

In addition, the role of temperature variability in structuring invertebrate communities will be assessed through quarterly surveys of aquatic macroinvertebrates in two river systems with different degrees of thermal variability. Such variability is believed to be important in maintaining temporal partitioning and spatial zonation of invertebrate species.

Since water temperature varies both spatially and temporally, an understanding of these dynamics is critical for ecologically sound river management. A map of preliminary thermal regions of South African rivers will therefore be developed by linking water temperature metrics to suitable spatial surrogates – such as air temperature, elevation or rainfall indices – using multiple linear regression modelling in conjunction with a suitable raster-based geographic information system. This will allow rivers to be classified into homogenous groups with similar thermal regimes, for which thermal guidelines can be set for the Ecological Reserve.

Finally, the project will explore the potential impact of climate and hydrological changes on selected aquatic organisms through scenario analyses, using agglomerative techniques to link biotic response to thermal triggers.

*The water temperature loggers are secured via steel cabling onto a bolt drilled into rocks in the river channel. Here Cameron Dallas displays some brotherly love by doing manual labour for his sister's project.*

*Masters student Vere Ross-Gillespy and Honours student Evans Simeku of the University of Cape Town's Freshwater Research Unit sample aquatic invertebrates.*

"For example, we hope to get a better idea of what's in store for aquatic organisms in mountain streams of the Western Cape, which are likely to be particularly hard hit by climate change given the prediction of rising air temperature and lower rainfall. This area is a biodiversity hotspot, with an incredible number of locally endemic insect and fish species," says Dallas. "We also know that fish are more susceptible to diseases and parasites when they are thermally stressed from elevated water temperatures, but what are the risks of outbreaks of pests such as mosquitoes and blackflies, which could have major implications for human health and agriculture?"

Time will tell, but the improved understanding gleaned through this research will hopefully facilitate the process of putting climate change contingency plans and mitigation measures in place. The insight obtained should also be useful in developing an ecologically meaningful water temperature classification for the Ecological Reserve, ensuring better protection of riverine ecosystems from more immediate threats caused by anthropogenic change.