Fraser River sockeye and migration mortality

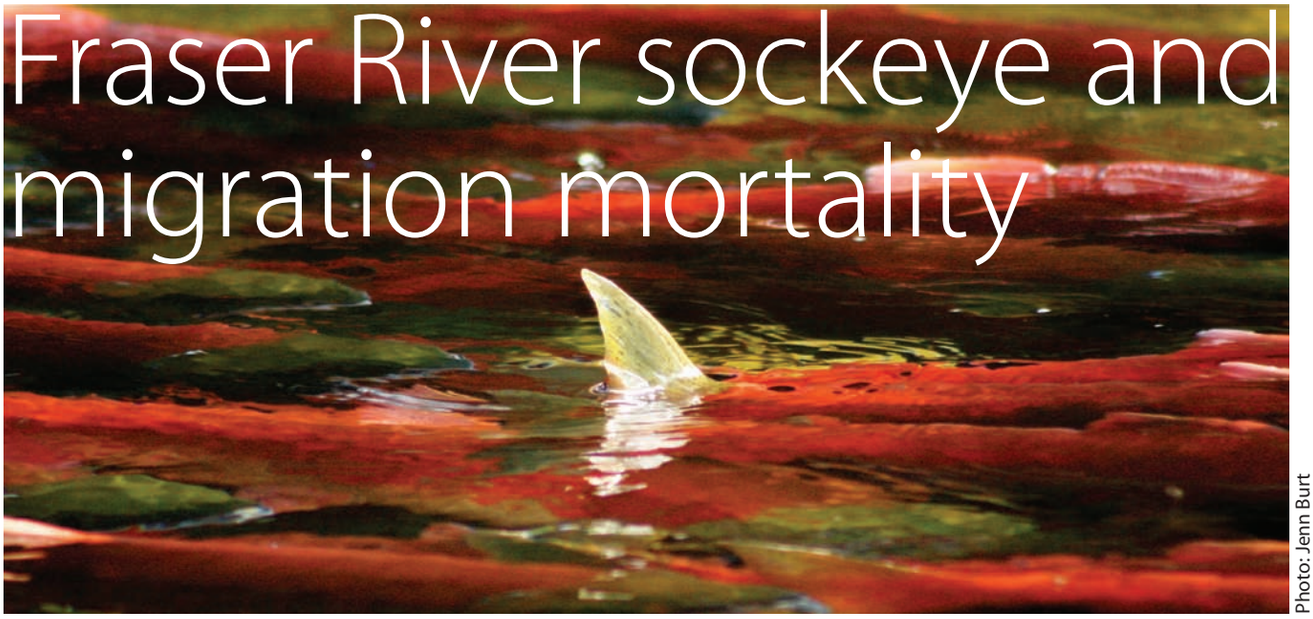

Photo: Jenn Burt

ABUNDANT AND SUSTAINABLE PACIFIC SALMON (*Oncorhynchus* spp) stocks are important economically, ecologically, and culturally to Canada. The five species of Pacific salmon represent some of Canada's last remaining large commercial fisheries on wild fish and recreational salmon fishing in British Columbia generates more than $1 billion annually in expenditures, supporting more than 10,000 jobs in communities throughout the province. Salmon are important components of food and nutrient webs in both freshwater and marine environments and they are integral to the mythology, spiritual integrity, and livelihoods of Pacific First Nations. Indeed, Pacific salmon are icons with abundant salmon confirming a healthy and productive environment in British Columbia.

So it is troubling that one of the most important and abundant groups of these fish, the Fraser River sockeye (*O nerka*), has exhibited a steady decline in productivity since the mid-1990s with the total adult return in 2009 being the lowest in over 50 years. This prompted the creation of a federal judicial inquiry, the Cohen Commission, an on-going investigation into the potential causes of this situation. It will make recommendations for improving the sustainability of sockeye salmon and the fishery.

"What is going on? How could this happen? Are salmon to go the way of the cod? Who is at fault, or to blame? … some have suggested the nation, and we, as individuals – are all to blame because this shows a failing to exercise wise stewardship over a precious resource." This statement, though potentially apropos to our current situation, was made in 1995 by the Honourable John Fraser in his final report to the federal Minister of Fisheries based on the '1994 missing salmon' inquiry that he led. Since 1992 there have been four federal inquiries or investigations into Fraser River sockeye declines and although they have differed in their mandates and specific goals, they reflect how much our society cares about salmon and how difficult it has been to manage and conserve this resource. To further highlight the complexity of our salmon system, Fraser sockeye adult returns in 2010 were one of the highest in the historical record.

Dr Scott Hinch is Director of the Pacific Salmon Ecology and Conservation Laboratory and a member of the Department of Forest Sciences at UBC. In 1994, one of Scott's first years studying Fraser sockeye, researchers in his group used radio transmitters to track adults as they migrated through the Fraser River canyon in July. That month was one of the warmest on record for salmon migrations. Water temperatures warmed as the month progressed, reaching 20 ºC, and they found that salmon started to migrate erratically and disappear as temperatures approached or exceeded 18 ºC. These were some of the first direct field observations that linked high temperatures to salmon mortality during migrations, and along with other 'evidence' presented at the 1994 inquiry led to a recommendation that the Department of Fisheries and Oceans (DFO; the federal agency that manages salmon) should be using information on water temperatures to aid with "in-season risk-averse management". In other words, to ensure that adequate numbers of fish reach spawning grounds during periods of high river temperatures, DFO must reduce harvest rates to compensate for natural migration mortality.

Since the mid-1990s Hinch's group has embarked on a highly collaborative research program that has grown over the years involving colleagues from several UBC departments, universities, private companies and fisheries management agencies, to examine how high temperatures kill salmon, populations differ in thermal tolerance, the condition of salmon prior to entering the river affects thermal tolerance, and how other in-river stressors affect migration mortality. They have been addressing these by linking large-scale telemetry observations with physiological and genomic assays on thousands of migrants, and conducting lab swimming performance and thermal tolerance experiments. High temperatures are currently a significant issue for Fraser

sockeye because the river has experienced ~ 2.0 ºC average summer warming compared to 60 years ago, with nearly half of that warming occurring since the early 1990s and water temperatures in 13 of the past 20 summers have been the warmest on record. In recent years migration mortality has ranged from 40–95% in many populations of Fraser sockeye.

There are more than 100 distinct populations of sockeye salmon in the Fraser River watershed and each must complete a unique migration route that varies in distance, elevation gain, river temperature and flow. In a recent study led by PhD student Erika Eliason and involving other students and colleagues from UBC Forestry and Zoology, published this year as a cover article in the journal *Science* (*Science* 332:109–112), researchers measured the swimming ability of adults from eight populations by monitoring metabolic and heart rates as they swam through a "fish treadmill" – a tunnel capable of producing varying water speeds and temperatures. The populations with the most difficult migrations were more athletic, displaying superior swimming ability and specialized heart adaptations. The optimal water temperature for a population, (the temperature at which the fish performed the best), matched the historical river temperatures encountered by each population on its migration routes, suggesting thermal adaptation. In water temperatures above their optimal, the salmon's swimming ability declined. Some populations, like those that spawn at Chilko Lake, were very resilient to high temperatures whereas others were less able to cope. Currently, the Fraser River's peak river temperatures during the summer months exceeds the optimal temperatures for every population examined and cardiovascular collapse is clearly one explanation for the migration mortality now observed within some populations. In a recent field telemetry study led by postdoctoral fellow Eduardo Martins (*Global Change Biology* 17:99–114) researchers confirmed that river migrating adults perished at rates and temperatures that were population-specific, and also confirmed that Chilko Lake sockeye survival was the least affected by warm river temperatures. However, high river temperatures are but one of several factors contributing to migration mortality. In another recent study published earlier this year (*Science* 331:214–217), Hinch's group demonstrated that salmon with a gene expression signature reflecting immune-suppression and disease, potentially caused by a virus, were much more likely to die during the migration.

Photo and front cover: Matt Casselman

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The science of understanding and predicting adult salmon migration mortality has come a long way in 20 years, and though there is still much to learn, the real challenge ahead lies in how to manage and conserve salmon as the climate, and Fraser River, continues to warm.

For further information contact Scott Hinch, Director, Pacific Salmon Ecology and Conservation Laboratory, Department of Forest Sciences, at scott.hinch@ubc.ca or visit http://faculty.forestry.ubc.ca/hinch/. For additional reading, a recent article in the journal Scientific American provides a comprehensive summary of the work of Hinch's group. This can be viewed at www.scientificamerican.com