BACKGROUNDER
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Technical Report Project 9 – Effects of climate change on Fraser River sockeye salmon

Project description: The researchers will compile and review all published evidence for climate change and climate-related effects on sockeye salmon in freshwater and marine habitats across all life stages, looking specifically for evidence of the effects of climate-related variables such as temperature, flow, salinity, pH, currents, primary productivity and species interactions on Fraser River sockeye survival. Researchers will also look at adult mortality during river migration and on spawning grounds.

Researchers:

Dr. Scott Hinch is a professor of fish ecology and conservation in the Department of Forest Sciences at the University of British Columbia (UBC). He currently teaches courses in aquatic ecology, salmon biology and fish conservation. He received BSc and MSc degrees from the University of Western Ontario, and a PhD from the University of Toronto in 1992. He began at UBC as a postdoctoral fellow and joined the professoriate in 1994. Over the past 20 years, he has investigated hypotheses about the role that environmental conditions have on salmon migration survival, behaviour, energetics, and physiology. He has also lead several long -term field experiments examining riparian timber harvest effects on stream temperature and habitat, fish abundance, growth, energetics, movements and habitat use.

Dr. Eduardo Martins is a post-doctoral fellow in UBC's Department of Forest Sciences. He was senior author of a report on the effects of river temperature and climate warming on stock-specific survival of adult migrating Fraser River sockeye salmon. He recently attended the International Symposium on Climate Change Effects on Fish and Fisheries in Sendai, Japan where he delivered a paper on effects of river temperature and climate warming on Fraser sockeye.

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Effect of climate change on sockeye survival

The report offers a qualitative assessment about how likely climate change over the past 20 years has affected survival in each stage of the sockeye's life. The report concludes that:

- survival of eggs has possibly increased (but not in all stocks)
- survival of alevins has unlikely changed
- survival of fry in lakes has possibly decreased
- survival of smolts and postsmolts has likely decreased
- survival of immatures in the ocean has possibly decreased
- survival of returning adults has very likely decreased (but not in all stocks)
- once on the spawning grounds, survival to spawn has possibly decreased (but not in all stocks)

This assessment suggests that climate change may have adversely affected survival of Fraser River sockeye salmon and therefore has possibly contributed to the declining abundance and productivity over the past 20 years.
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It is also likely that inter-annual variability in climate conditions has contributed to the extreme disparity in abundance of returning adults in 2009 and 2010. Sea surface temperatures were unusually warm in 2007, then relatively cooler in 2008, the years that those cohorts went to sea.

Adult mortality during river migration and on spawning grounds

Warming river temperatures have been one of the largest environmental challenges that migrating adult Fraser sockeye have had to deal with over the past 20 years. The Fraser River is now about two degrees warmer in the summer compared to 60 years ago. Much of that warming has occurred within the last 20 years. Water temperatures in 13 of the last 20 summers have been the warmest on record. Since 1995, Late-run sockeye stocks have been entering the Fraser River three to six weeks earlier than normal, where they encounter temperatures up to five degrees warmer than they once encountered, and they are spending longer in freshwater because spawning migration dates have not changed.

En route loss (an index of levels of salmon that may die in fresh water during their migration to the spawning grounds) has been increasing, with recent years having some the relatively highest levels, especially for Early Stuart and Late-run timing groups of Fraser sockeye. For a majority of stocks, *en route* loss exceeded 50 per cent for more than half the years between 1996 and 2008. *En route* mortality, which has been assessed with telemetry research, has revealed stock-specific patterns likely related to thermal tolerance. Laboratory research confirms that Summer-runs have the greatest tolerance for rising temperatures, and early migrating Late-run stocks are particularly poor at dealing with high temperatures and they are also exposed to freshwater diseases for prolonged periods as they now reside longer in fresh water.

En route and pre-spawn mortality (salmon that survive to the spawning grounds but die before they successfully deposit all of their eggs) in adult sockeye salmon are significant factors that reduce the number of effective female spawners, and may pose a risk to the long-term viability of some Fraser River sockeye stocks.

Recommendations

The report suggests future research be directed in areas such as:

- Electronic tagging and experimentally exposing fish to varying temperature, salinity, pH or parasites to better understand marine survival, predict *en route* and pre-spawn mortality, and stress-related mortality.
- Field-based research on early life stages in freshwater.
- Better assess the extent and consequences of stock and gender differences in survival of migrating adult sockeye.
- Research examining cumulative impacts, carry-over effects and effects among generations.
- Climate change modeling to quantify the impact of climate warming on future trends in Fraser sockeye productivity and abundance.