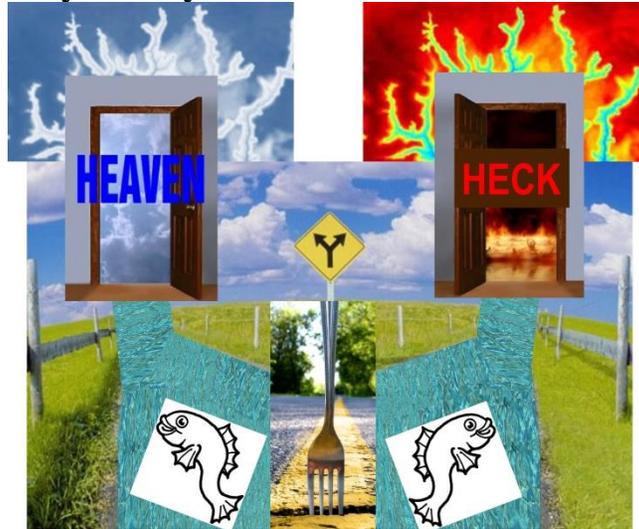


Climate-Aquatics Blog #63: Navigating stream thermalscapes to thrive or merely survive

Choose wisely when you come to a fork in the thermalscape



Hi Everyone,

Anyone that manages, researches, fishes for, or otherwise regularly interacts with fish knows that temperature is of paramount importance—second only to water & having enough of it to swim in. Fish are, after all, ectotherms that are physiologically constrained to operate within well-defined and sometimes narrow thermal niches. That said, there is always wiggle room and today we're highlighting some ways (& whys) for fish doing the wiggling that they do. In the first study, Armstrong and Schindler (graphic 1; study attached) describe how juvenile coho in an Alaska stream move among different thermal habitats before/after consuming sockeye salmon eggs. After gorging themselves on eggs in the cold habitats where sockeye spawned, the coho moved to warmer habitats to increase their digestive efficiency and work through their food comas more quickly.

Quite smart and good if you're a fish living within a relatively cool portion of your species' range and thoughts of extreme heat denaturing your proteins are far away from your pea-sized brain. But fish are forced physiologically to wiggle for very different reasons in the warm portion of their biothermalverse. As Chadwick & colleagues show, lab and field temperatures near the upper thermal limit of a cold-water species like brook trout trigger the production of thermal-shock proteins (graphic 2; study hyperlinked here

<http://conphys.oxfordjournals.org/content/3/1/cov017.full.pdf+html>). And as that internal thermal unpleasantness grows, fish start to “freak-out” and actively search for local cool-water anomalies. Where they find those areas, dense aggregations may form—a phenomenon that Dugdale & colleagues (graphic 3; study hyperlinked here

https://www.researchgate.net/profile/Stephen_Dugdale) document with an innovative application of PIT tag antenna arrays that tracked juvenile Atlantic salmon movements during a heat wave.

In a similar vein, Hillyard and Keeley (graphic 4; study hyperlinked here

<https://sites.google.com/a/isu.edu/fish-ecology-laboratory/publications/pdfs/Hillyard%20and%20Keeley%202012.pdf?attredirects=0&d=1>) used

a combination of TIR flight imagery, fixed site temperature sensors, and temperature sensitive biotelemetry tags to describe movements by adult cutthroat trout to cooler habitats during especially warm summer periods.

Thus, temperature can be friend or foe depending on the local context. But in aquatic environments that represent the warm end of the thermal spectrum for a given species, important questions to resolve are “how much resilience do thermally-stressed populations have before they go into serious decline?” And “if an important thermal threshold is likely to be passed as temperatures continue increasing, are there habitat impairments that could be ameliorated (blog #'s [55](#) and [58](#)) to mitigate future warming and increase population resilience?” Because once the fish are “freaking out”, it’s a bad sign that the clock is ticking & we would be wise to heed the message our finned friends are sending us.

Until next time, best regards,
Dan



Now Tweeting at [Dan Isaak@DanIsaak](#)



Thermal conditioning of juvenile coho foraging behavior

“See salmon egg, eat salmon egg...”

“I may have overdone it...”

“time to chill with my homies in a warm place ...”

Egg food source, but best digestion is elsewhere

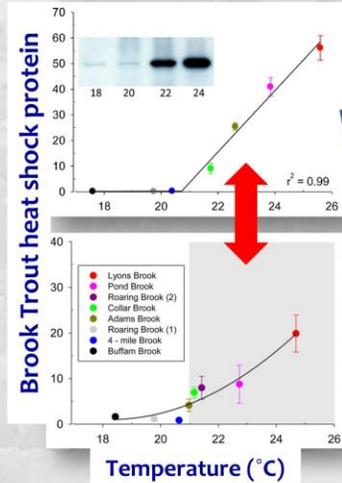
Armstrong & Schindler. 2013. Going with the Flow: Spatial Distributions of Juvenile Coho Salmon Track an Annually Shifting Mosaic of Water Temperature. *Ecosystems* **16**:1429-1441.

The infographic features two vertical graphs with 'Distance upstream' on the y-axis (0 to 2000). The left graph shows 'Egg food source' with blue circles and 'Best digestion' with red circles. The right graph shows 'Egg food source' with red circles and 'Best digestion' with blue circles. Red arrows point from the top graph to the bottom graph, indicating a shift in behavior. A vertical image of a forest fire is on the left, and images of juvenile coho salmon are on the right.

I'm a cold-water fish, is it surprising that the heat makes my cells sweat?

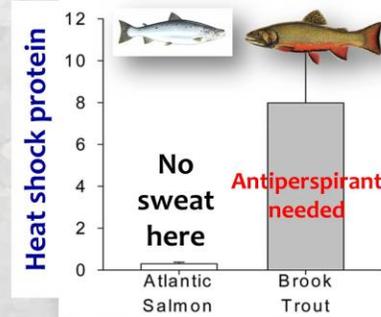


Laboratory results match field results



But then...

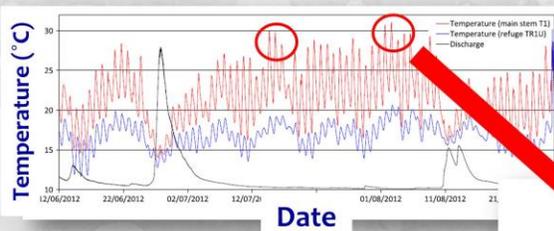
Same streams, different species, different sweatiness...



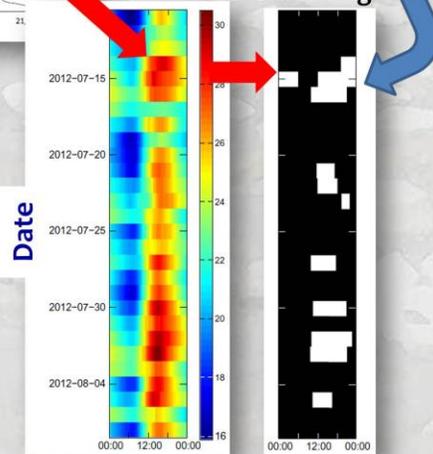
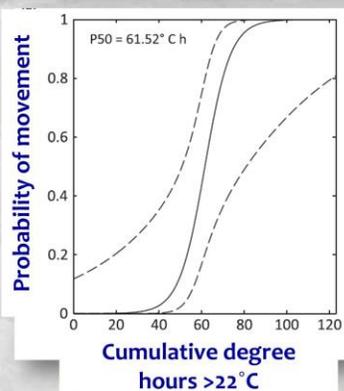
Chadwick et al. 2015. Thermal onset of cellular and endocrine stress responses correspond to ecological limits in brook trout, an iconic cold-water fish. *Conservation Physiology* 3:doi 10.1093/conphys/cov017

Go here for this article: <http://conphys.oxfordjournals.org/content/3/1/cov017.full.pdf+html>

Too Hot, Time to Move to Cooler Microclimes...



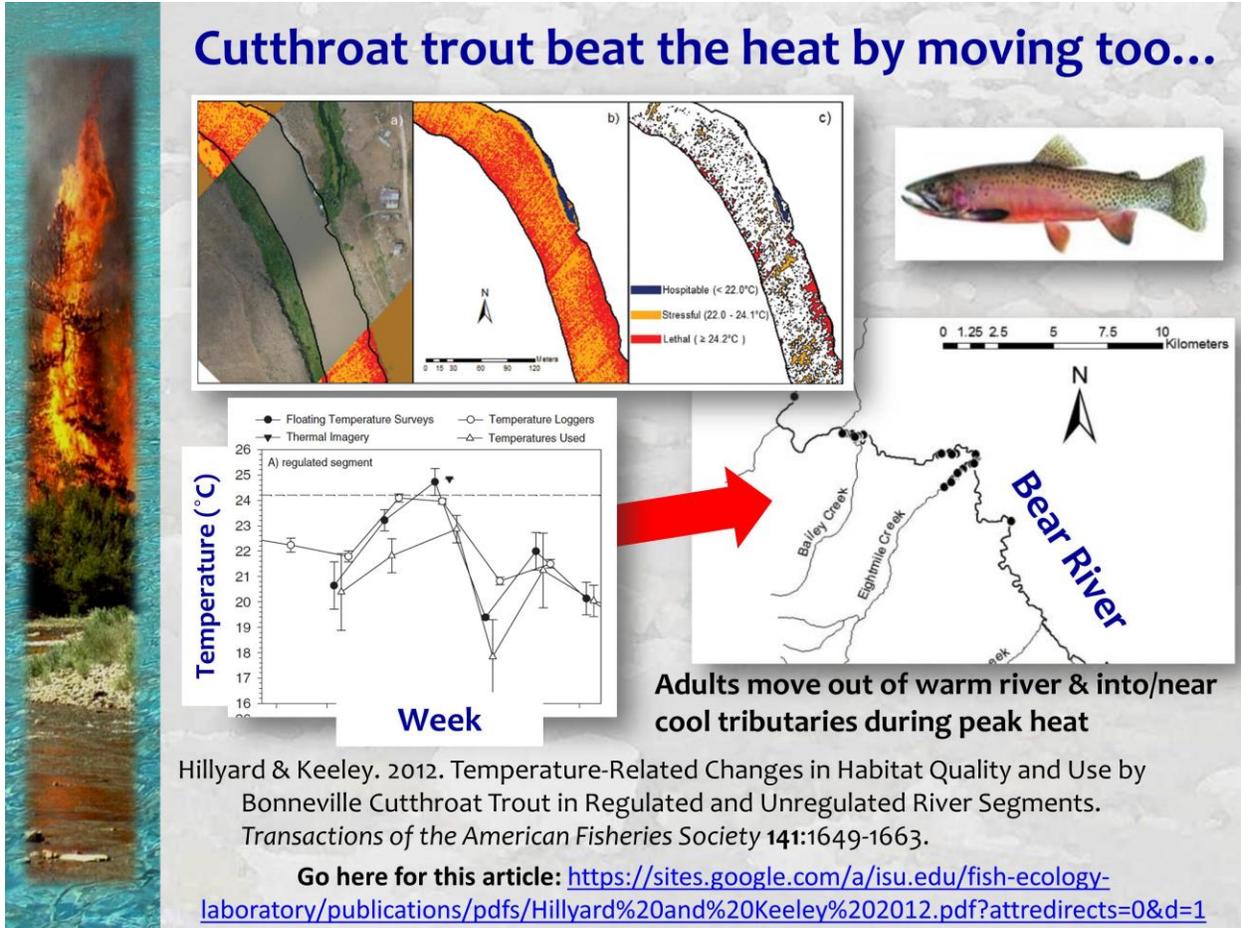
Fish aggregation event timing...



Dugdale et al. 2015. Main stem movement of Atlantic salmon parr in response to high river temperature. *Ecology of Freshwater Fish* 24:doi: 10.1111/eff.12224.

Go here for this article: https://www.researchgate.net/profile/Stephen_Dugdale

Cutthroat trout beat the heat by moving too...



Welcome to the Climate-Aquatics Blog. For those new to the blog, previous posts with embedded graphics can be seen by clicking on the hyperlinks at the bottom or by navigating to the blog archive webpage here: (http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temp/stream_temperature_climate_aquatics_blog.html). The intent of the Climate-Aquatics Blog is to provide a means for the 9,214 (& growing) field biologists, hydrologists, anglers, students, managers, and researchers currently on this mailing list across North America, South America, Europe, and Asia to more broadly and rapidly discuss topical issues associated with aquatic ecosystems and climate change. Messages periodically posted to the blog highlight new peer-reviewed research and science tools that may be useful in addressing this global phenomenon. Admittedly, many of the ideas for postings have their roots in studies my colleagues & I have been conducting in the Rocky Mountain region, but attempts will be made to present topics & tools in ways that highlight their broader, global relevance. I acknowledge that the studies, tools, and techniques highlighted in these missives are by no means the only, or perhaps even the best, science products in existence on particular topics, so the hope is that this discussion group engages others doing, or interested in, similar work and that healthy debates & information exchanges occur to facilitate the rapid dissemination of knowledge among those concerned about climate change and its effects on aquatic ecosystems.

If you know others interested in climate change and aquatic ecosystems, please forward this message to them. If you do not want to be contacted again in the future, please reply to that effect and you will be delogged.

Previous Blogs...

Climate-Aquatics Overviews

Blog #1: [Climate-aquatics workshop science presentations available online](#)

Blog #2: [A new climate-aquatics synthesis report](#)

Climate-Aquatics Thermal Module

Blog #3: [Underwater epoxy technique for full-year stream temperature monitoring](#)

Blog #4: [A GoogleMap tool for interagency coordination of regional stream temperature monitoring](#)

Blog #5: [Massive air & stream sensor networks for ecologically relevant climate downscaling](#)

Blog #6: [Thoughts on monitoring air temperatures in complex, forested terrain](#)

Blog #7: [Downscaling of climate change effects on river network temperatures using inter-agency temperature databases with new spatial statistical stream network models](#)

Blog #8: [Thoughts on monitoring designs for temperature sensor networks across river and stream basins](#)

Blog #9: [Assessing climate sensitivity of aquatic habitats by direct measurement of stream & air temperatures](#)

Blog #10: [Long-term monitoring shows climate change effects on river & stream temperatures](#)

Blog #11: [Long-term monitoring shows climate change effects on lake temperatures](#)

Blog #12: [Climate trends & climate cycles & weather weirdness](#)

Blog #13: [Tools for visualizing local historical climate trends](#)

Blog #14: [Leveraging short-term stream temperature records to describe long-term trends](#)

Blog #15: [Wildfire & riparian vegetation change as the wildcards in climate warming of streams](#)

Blog #23: [New studies describe historic & future rates of warming in Northwest US streams](#)

Blog #24: [NoRRTN: An inexpensive regional river temperature monitoring network](#)

Blog #25: [NorWeST: A massive regional stream temperature database](#)

Blog #26: [Mapping thermal heterogeneity & climate in riverine environments](#)

Blog #40: [Crowd-sourcing a BIG DATA regional stream temperature model](#)

Blog #60: [Bonus Blog: New report describes data collection protocols for continuous monitoring of temperature & flow in wadeable streams](#)

Blog #61: [Significant new non-American stream temperature climate change studies](#)

Blog #62: [More Bits about the How, What, When, & Where of Aquatic Thermalscapes](#)

Climate-Aquatics Hydrology Module

Blog #16: [Shrinking snowpacks across the western US associated with climate change](#)

Blog #17: [Advances in stream flow runoff and changing flood risks across the western US](#)

Blog #18: [Climate change & observed trends toward lower summer flows in the northwest US](#)

Blog #19: [Groundwater mediation of stream flow responses to climate change](#)

Blog #20: [GIS tools for mapping flow responses of western U.S. streams to climate change](#)

Blog #21: [More discharge data to address more hydroclimate questions](#)

Blog #22: [Climate change effects on sediment delivery to stream channels](#)

Climate-Aquatics Cool Stuff Module

Blog #27: [Part 1, Spatial statistical models for stream networks: context & conceptual foundations](#)

Blog #28: [Part 2, Spatial statistical models for stream networks: applications and inference](#)

Blog #29: [Part 3, Spatial statistical models for stream networks: freeware tools for model implementation](#)

Blog #30: [Recording and mapping Earth's stream biodiversity from genetic samples of critters](#)

Blog #53: [DNA Barcoding & Fish Biodiversity Mapping](#)

Climate-Aquatics Biology Module

Blog #31: [Global trends in species shifts caused by climate change](#)

Blog #32: [Empirical evidence of fish phenology shifts related to climate change](#)

Blog #33: [Part 1, Fish distribution shifts from climate change: Predicted patterns](#)

- Blog #34: [Part 2, Fish distribution shifts from climate change: Empirical evidence for range contractions](#)
- Blog #35: [Part 3, Fish distribution shifts from climate change: Empirical evidence for range expansions](#)
- Blog #36: [The “velocity” of climate change in rivers & streams](#)
- Blog #37: [Part 1, Monitoring to detect climate effects on fish distributions: Sampling design and length of time](#)
- Blog #38: [Part 2, Monitoring to detect climate effects on fish distributions: Resurveys of historical stream transects](#)
- Blog #39: [Part 3, Monitoring to detect climate effects on fish distributions: BIG DATA regional resurveys](#)
- Blog #41: [Part 1, Mechanisms of change in fish populations: Patterns in common trend monitoring data](#)
- Blog #42: [BREAKING ALERT! New study confirms broad-scale fish distribution shifts associated with climate change](#)
- Blog #56: [New studies provide additional evidence for climate-induced fish distribution shifts](#)
- Blog #43: [Part 2, Mechanisms of change in fish populations: Floods and streambed scour during incubation & emergence](#)
- Blog #44: [Part 3, Mechanisms of change in fish populations: Lower summer flows & drought effects on growth & survival](#)
- Blog #45: [Part 4, Mechanisms of change in fish populations: Temperature effects on growth & survival](#)
- Blog #46: [Part 5, Mechanisms of change in fish populations: Exceedance of thermal thresholds](#)
- Blog #47: [Part 6, Mechanisms of change in fish populations: Interacting effects of flow and temperature](#)
- Blog #48: [Part 7, Mechanisms of change in fish populations: Changing food resources](#)
- Blog #49: [Part 8, Mechanisms of change in fish populations: Non-native species invasions](#)
- Blog #50: [Part 9, Mechanisms of change in fish populations: Evolutionary responses](#)
- Blog #51: [Part 10, Mechanisms of change in fish populations: Extinction](#)
- Blog #52: [Review & Key Knowable Unknowns](#)

Climate-Aquatics Management Module

- Blog #54: [Part 1, Managing with climate change: Goal setting & decision support tools for climate-smart prioritization](#)
- Blog #55: [Part 2, Managing with climate change: Streams in channels & fish in streams](#)
- Blog #57: [Identifying & protecting climate refuge lakes for coldwater fishes](#)
- Blog #58: [Part 3, Managing with climate change: Maintaining & improving riparian vegetation & stream shade](#)
- Blog #59: [Part 4, Managing with climate change: Keeping water on the landscape for fish \(beaverin' up the bottoms\)](#)