Climate-Aquatics Blog #55:
Managing with climate change, part 2: Streams in channels & fish in streams

“Whiskey is fer drinkin, water is fer fightin”

Or so goes the saying from spaghetti westerns about the importance of water in the semi-arid West. Water’s always been a touchy subject where it’s dry, and will become even more so as human populations continue to grow. Since fish have a certain proclivity for the substance too, our use of it sometimes puts them in a bit of a bind. A simple and highly effective management strategy, therefore, is keeping water in streams and fish in those same streams. That’s a lot trickier than it sounds given the forces at play, but there are ways to do both.

First, it’s useful to have a sense of the magnitude of what we’re talking about. In the United States alone, we withdraw or divert 400 billion gallons of freshwater per day for various municipal, industrial, and agricultural purposes (Kenny & colleagues – study hyperlinked here: http://pubs.usgs.gov/circ/1344/). That’s B as in BILLIONS each day, and that’s a lot of aqueous matter our fishy friends might otherwise be using as habitat. There are many ways that water is withdrawn from freshwaters but one of the more common on smaller systems is to simply create small checkdams that create a bit of hydraulic head and then divert a portion of the flow into a ditch. It’s an eye opener to see just how common those sorts of diversions are in some river networks—we’re talking about hundreds of diversions in some cases (graphic 1). The issues these diversions create are two-fold. First, obviously, there’s less water in the stream channel to provide habitat. Second, in the process of diverting water, we also sometimes divert fish into places they shouldn’t be (graphic 2). There are some estimates of how many fish can be lost that way (see Roberts & Rahel – study hyperlinked here: http://www.uwyo.edu/frahel/pdfs/roberts-2008-1.pdf), but it seems to be a greatly underappreciated problem in many places (see King & O’Connor – study attached).

So let's first examine that latter problem—fish being diverted into the wrong places as they swim through networks sometimes acting as sieves. In a detailed treatment of the topic, Walters & colleagues studied the survival of juvenile Chinook salmon in an eastern Idaho river that were migrating out to the ocean (graphic 3; study hyperlinked here: http://www.wyocoopunit.org/index.php/download_file/view/1312/220/). Not surprisingly, they found that a higher proportion of juveniles were diverted when a higher proportion of the overall flow was diverted. That issue was well-known in the basin for a long time, so a lot of people & agencies have committed time & resources to put fish screens on many diversions in an attempt to keep fish in the river where they belong. Those efforts have made a big difference, as mortality rates now are much lower at screened diversions than unscreened ones (graphic 3).

It's a great success story, but there's always a potential climate fly in the ointment. In a subsequent companion study, Walters & colleagues (graphic 4; study hyperlinked here: http://www.wyocoopunit.org/index.php/download_file/view/1515/220/) asked how future climates—specifically changes in summer temperatures and spring flows—might affect juvenile survival in those same salmon populations. First they documented historical linkages between inter-annual variation in those climate variables and salmon survival. Then they asked what the climate model projections were for those variables and used the new values to rerun the fish survival models. They found that if the future is wet, survival rates would remain pretty consistent with what they have been. But if the future is a drier one, then survival rates would decline, and water diversions would compound that decline.

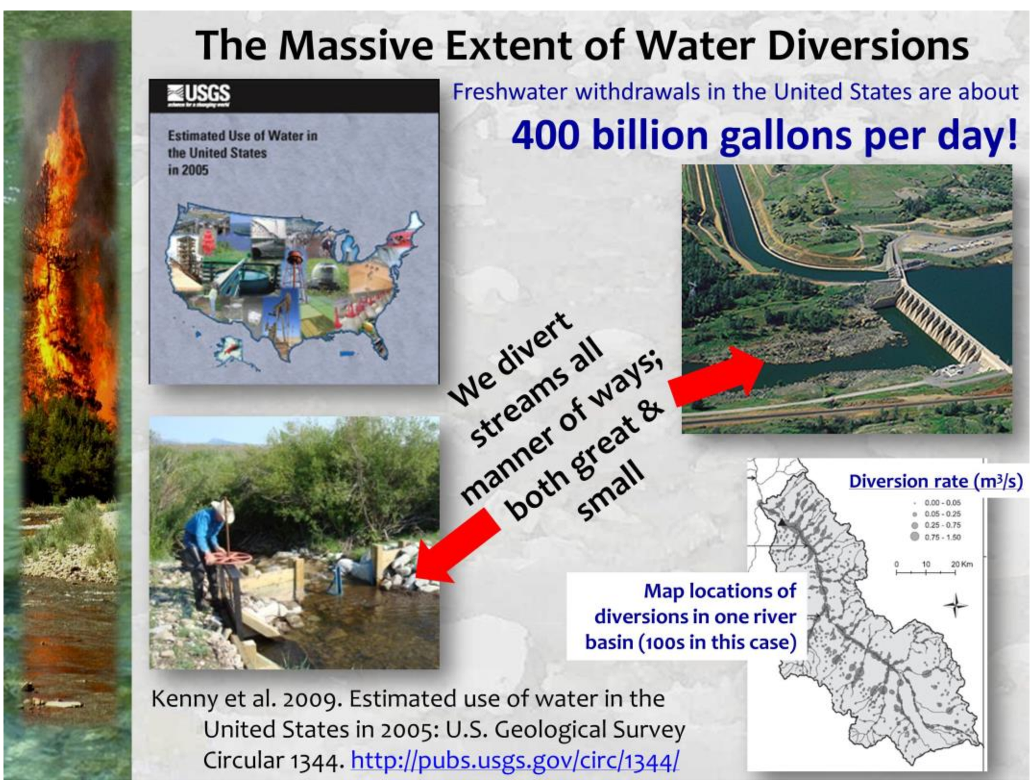
And that points us back to one of the key uncertainties regarding the climate models. In many places, they don't provide much resolution regarding whether the future will be wetter or drier (Blog #18). But there's new science emerging to suggest it will be drier in at least some places (see Luce & colleagues "The Missing Mountain Water" – study hyperlinked here: http://www.sciencemag.org/content/342/6164/1360.full.pdf). That stems from the fact that the climate models for some mountainous areas have been missing important historical trends towards less precipitation because the monitoring networks haven't adequately represented precipitation at high elevations. It's sparking a lot of discussion and debate in the hydroclimate world (see Dettinger "Impacts in the Third Dimension" hyperlinked here: http://aquadoc.typepad.com/files/ngeo2096-aop.pdf) so expect to hear more about this in future years as science works to resolve this fundamentally important question.

So even if we catch a break and the stream freshwater pie does grow a bit this century, with more human mouths eating the pie, there could still be fewer pieces left for fish. Given the uncertainties in water, but strong certainties in human population growth, one of the smartest ways of making the pie last longer is to use it more efficiently. And in the case of water use, there's often an enormous amount that can be done relatively inexpensively to improve the efficiency of water delivery systems & monitoring networks using modern technologies (Blog #21). Those systems are being adopted in many places, but wanted to highlight another success story that Mike Roberts and his colleagues are pulling off in the Big Hole River of western Montana (graphic 5). There, through dedicated efforts over many years & partnerships & collaborations with willing landowners, they've implemented a modern system that greatly increases the efficiency of agricultural water use. The landowners still get what they need, but so do the rare and fantastically finned grayling populations that have called the Big Hole home for thousands of years. What's going on in that river basin is climate adaptation in action at the grassroots level. Similar efforts, multiplied thousands of times over in thousands of river basins, are exactly what local solutions to global climate change will look like this century.

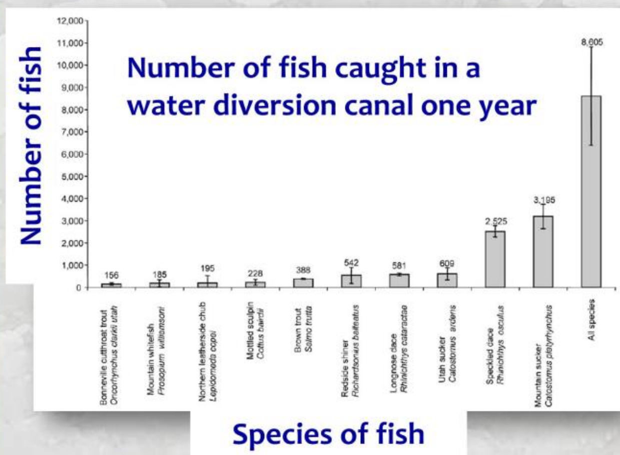
Collectively, those river basin efforts will add up to big things for biodiversity and our fishy friends, but even as we become hyper-efficient, it's still a virtual certainty that we'll have to make some hard choices in some places. That's where water issues often remind me of a quote from Ted Bjornn, who was my graduate research advisor 20 years ago & was one of the world's foremost salmon researchers in the last decades of the 20th Century. Ted said, "We wouldn't have the luxury of caring about fish if we didn't have a strong economy and weren't relatively well off…" You see, Ted grew up in farming country & knew first-hand that wealth ultimately flows from our use of some of the Earth's resources. But that same Earth and its critters also inspired him to devote his life and career to the study & conservation of salmon. That's the dichotomy we all face and have to balance as we work our way through this. How do we simultaneously support ourselves and the things we care about in the natural world? It's certainly possible at some level but we can't have everything everywhere and maximizing what we bring with us through this transitional century will require being really smart, efficient, and willing to make choices (Blog 54).

Until next time, best regards,
Dan

Now Tweeting at Dan Isaak@DanIsaak



Sometimes Our Fishy Friends Get Diverted With the Water

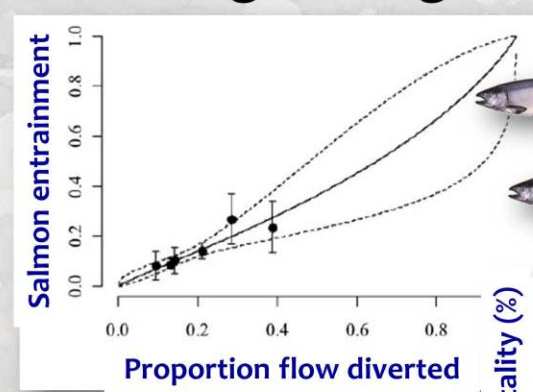


That's bad when the spigot's turned off…

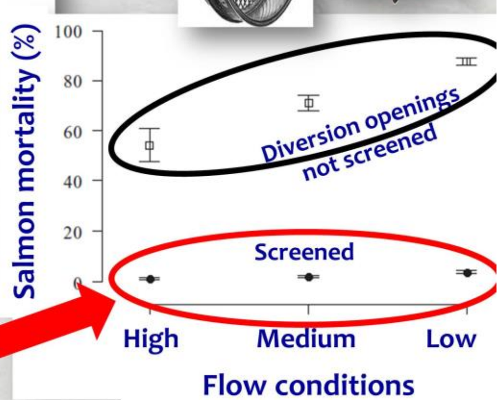
Roberts & Rahel. 2008. Irrigation canals as sink habitat for trout and other fishes in a Wyoming drainage. *Transactions of the American Fisheries Society* **137**:951-961. http://www.uwyo.edu/frahel/pdfs/roberts-2008-1.pdf

King & O'Connor. 2007. Native fish entrapment in irrigation systems: a step towards understanding the significance of the problem. *Ecological Management & Restoration* **8**:32-37.

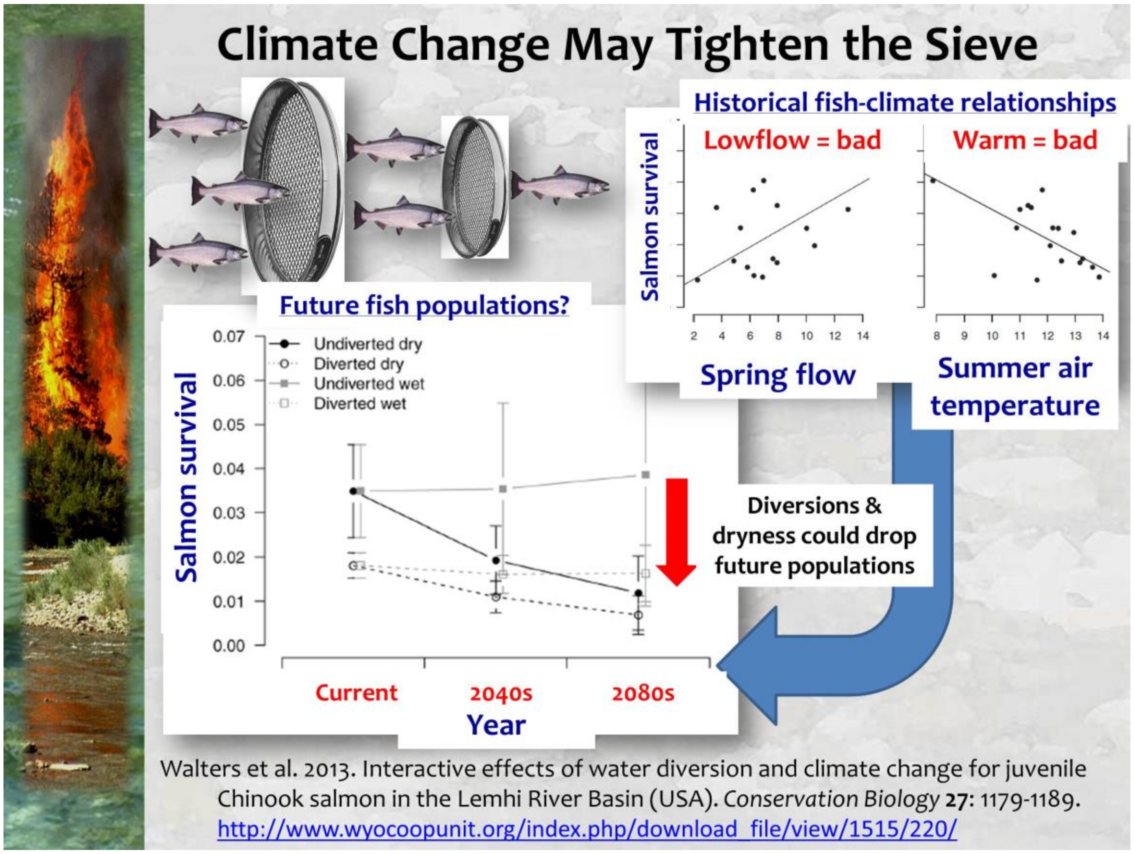
Swimming Through a Fish Sieve

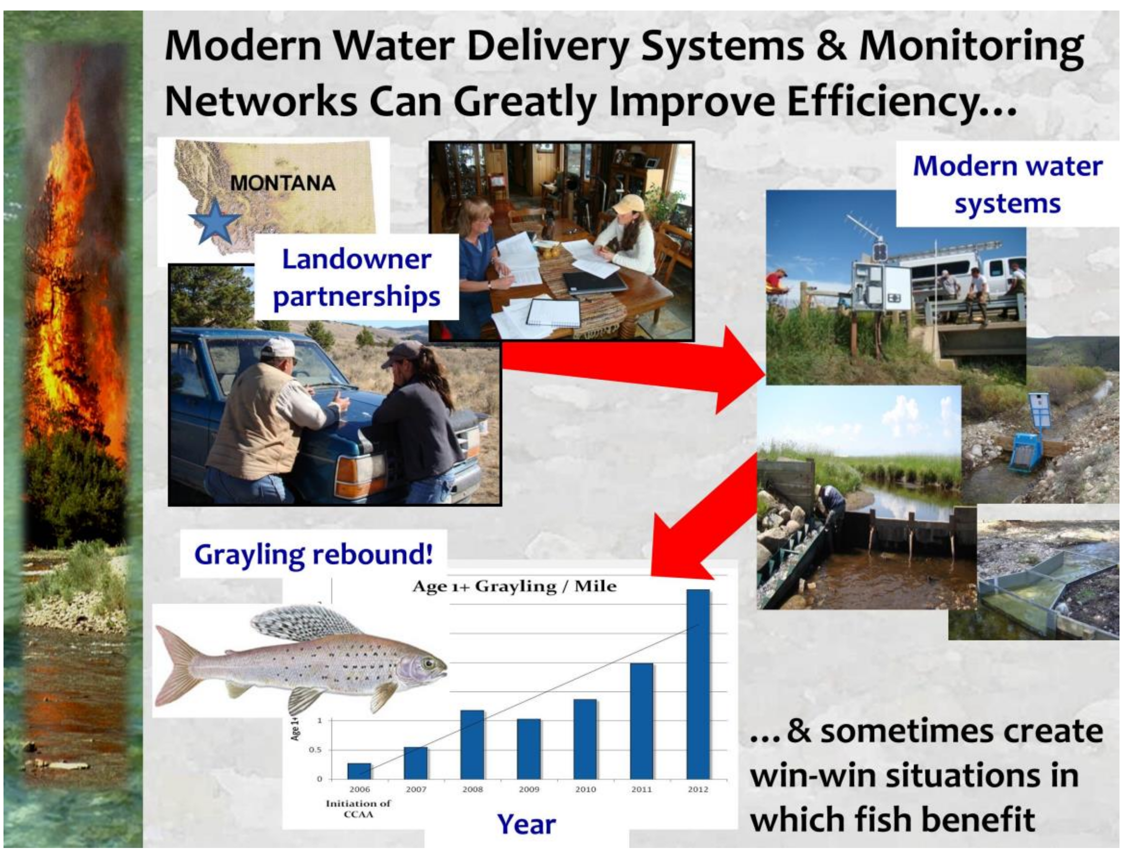


Fish screens keep fish alive



Walters et al. 2012. Quantifying cumulative entrainment effects for Chinook salmon in a heavily irrigated watershed. *Transactions of the American Fisheries Society* **141**:1180-1190. http://www.wyocoopunit.org/index.php/download_file/view/1312/220/


Climate Change May Tighten the Sieve
Historical fish-climate relationships
Lowflow = bad
Warm = bad
Salmon survival
Spring flow
Summer air temperature
Future fish populations?
Undiverted dry
Diverted dry
Undiverted wet
Diverted wet
Salmon survival
Diversions & dryness could drop future populations
Current
2040s
2080s
Year
Walters et al. 2013. Interactive effects of water diversion and climate change for juvenile Chinook salmon in the Lemhi River Basin (USA). *Conservation Biology* **27**: 1179-1189.
http://www.wyocoopunit.org/index.php/download_file/view/1515/220/


Modern Water Delivery Systems & Monitoring Networks Can Greatly Improve Efficiency…
MONTANA
Landowner partnerships
Modern water systems
Grayling rebound!
Age 1+ Grayling / Mile
Initiation of CCAA
Year
… & sometimes create win-win situations in which fish benefit

That's One Fantastically Finned Fish…

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 7,451 (& 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 de-blogged.

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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

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

Climate-Aquatics Biology Module
Blog #30: Recording and mapping Earth's stream biodiversity from genetic samples of critters
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 #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
Blog #53: DNA Barcoding & Fish Biodiversity Mapping

Climate-Aquatics Management Module
Blog #54: Part 1, Managing with climate change: Goal setting & decision support tools for climate-smart prioritization

Future topics…
Climate-Aquatics End Game