Climate-Aquatics Blog #35: Part 3, Fish distribution shifts from climate change: Empirical evidence for range expansions

Are cold fish basking in balmy new habitats somewhere? 

Hi Everyone,
So we're addressing the same question this time as last (i.e., are fish distributions shifting as per the predictions from the bioclimatic models?) but now we're looking at the other end of the thermal spectrum; to streams that were previously too cold for some species. Just as we'd predict species & local populations to be lost from warm habitats as climate change proceeds, some critters should also be expanding into new habitats elsewhere (graphic 1). This one's a bit tougher to tease out a climate effect due to the global pandemic of non-native species invasions that provide ample examples of distributions expanding. In most cases, however, those invaders are just running willy-nilly through new environments rather than basking in newly unfrozen ones. So addressing the range expansion-climate change question most precisely requires looking at species that have been parts of stream ecosystems long enough to have more or less filled their ecological niches. The best candidates for this will usually be natives (or a non-native that's been there a long time) & we'd want to focus our attention on population boundaries in cold places like the upstream distributional extent in a mountain stream or the northerly extent of a species' range. As was the case with empirical evidence of range contractions last time (blog #34), there aren't a lot of case histories documenting climate-related range expansions for fish species and I had to stretch to find a few.

The first study is an overview of the work that Milner and colleagues have been doing in Glacier Bay National Park the last several decades in Alaska (graphic 2). It's something of a special case since huge chunks of ice aren't usually sitting on top of most streams, but it does illustrate the general point in a brute force sort of way. As the glaciers have melted and retreated in GBNP over the last few hundred years, new streams and associated ecosystems have been developing as temperatures gradually increased. Long-term monitoring data over a 30+ year period documented the colonization of some of these streams by Dolly Varden, then coho salmon, followed by chum salmon, and coast range sculpin. Moreover, because the glacial retreat varies in age across many streams, the colonization sequence is at different stages throughout the GBNP & interested readers should check out some of Milner's earlier papers for more of those details.

The second study is less than perfect, since rather than looking at fish, we're looking at bugs that are typically considered fish food (no offense to the entomologists in the room). Moreover, these bugs disperse mainly by flight after emerging from streams and lakes where they spend their juvenile stages (but there's just not a lot to choose from in this genre, so we'll go with it). In the study by Hickling and colleagues, distributions of 37 Odonate species (dragonflies and damselflies) were assessed across Britain between two periods (1960-1970 and 1985-1995). Of the 37 species examined, 34 exhibited a northward range shift over this time, with the average

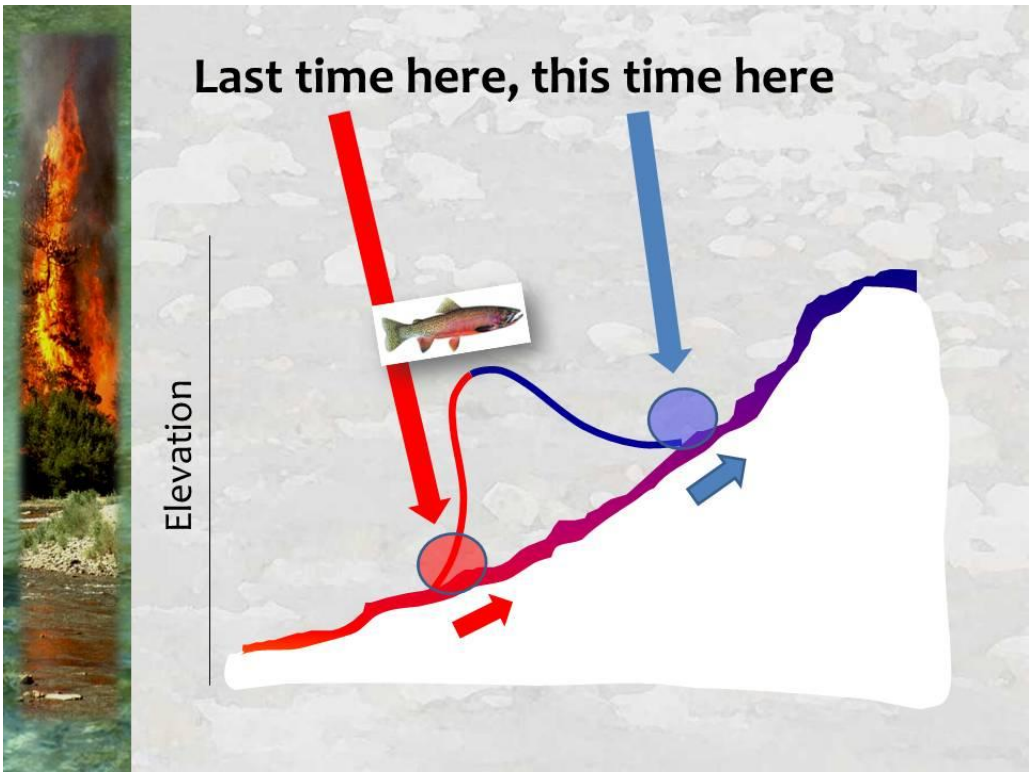
shift being 74 kilometers (graphic 3). This study is a great example of the utility of historical survey data—a topic we'll be exploring in much more detail in future blogs.

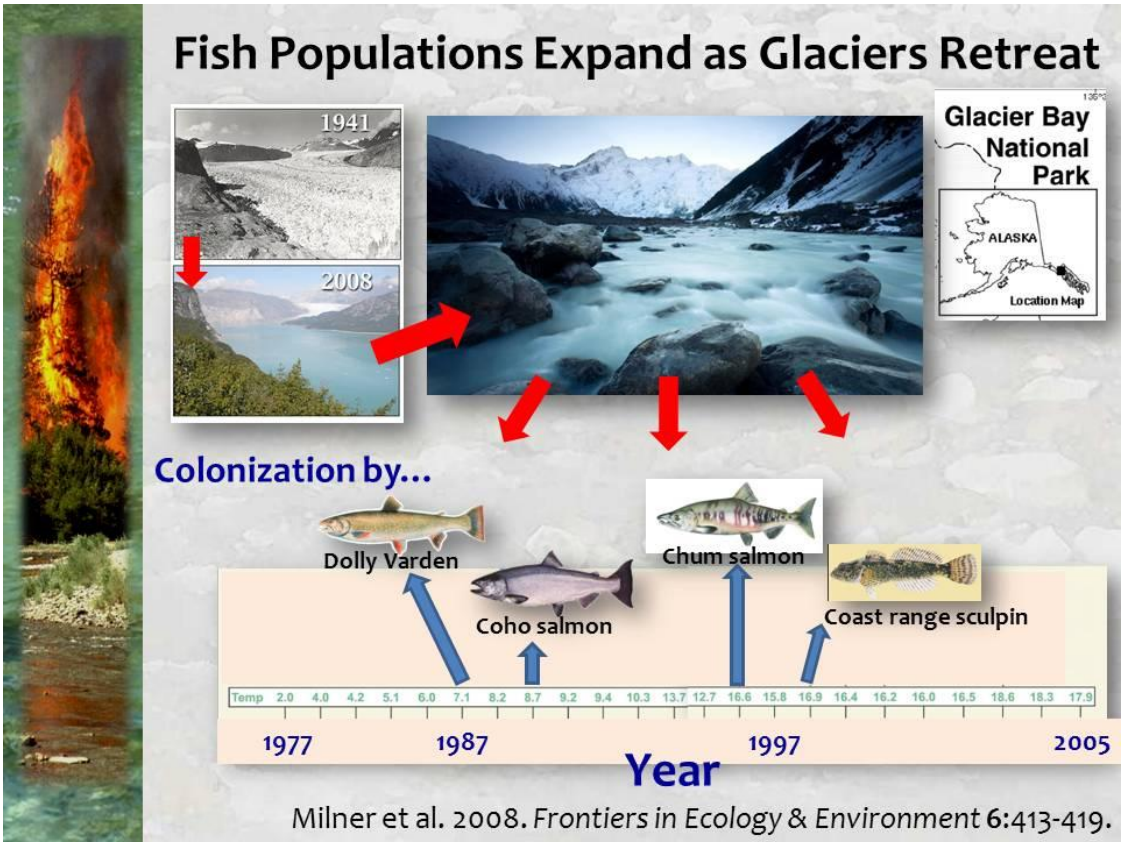
So I've no doubt missed a few, but the 4 studies highlighted in this blog and the previous one constitute a significant amount of the empirical evidence that exists for distribution shifts in freshwater organisms related to climate change. Given that freshwater ecosystems contain a disproportionate amount of biodiversity (something like 6% of all described species occur in freshwater environments that cover < 1% of the Earth's surface), we have some work to do to catch the biological evidence up to the model predictions (blog #33) for these important ecosystems. That evidence can be accumulated relatively quickly using existing databases, by mimicking some of the study designs used previously in other disciplines, and tailoring the questions specifically to aquatic environments. But before plunging ahead, it's good to think critically about how and where to look and what we'd expect to see if warming trends are truly causing widespread distribution shifts. By gathering ourselves first, we can develop and test some interesting hypotheses along the way, add scientific rigor to the work, and maximize what is learned from the global warming experiment that's being run.

Until next time, best regards,

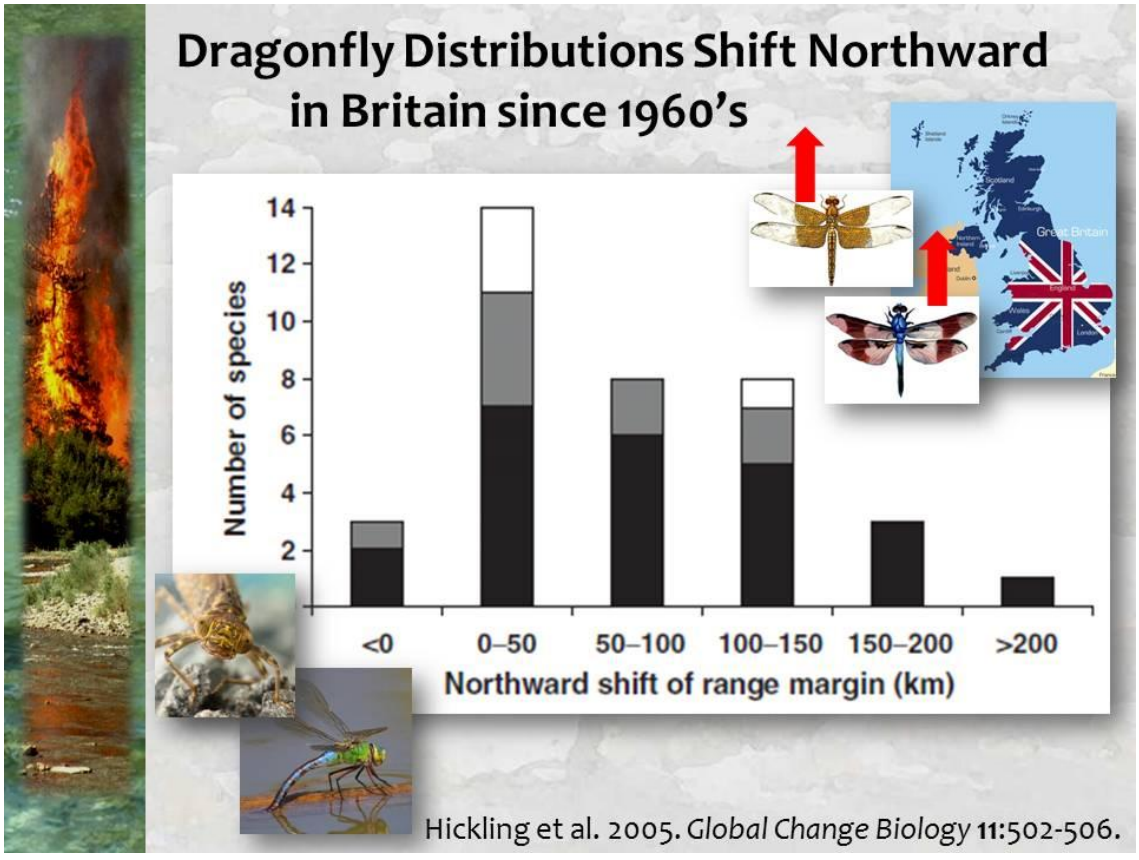
Dan

Now Tweeting at Dan Isaak@DanIsaak





Milner et al. 2008. *Frontiers in Ecology & Environment* 6:413-419.



Hickling et al. 2005. *Global Change Biology* **11**:502-506.

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 on our Forest Service site at: (http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temp/stream_temperature_climate_aquatics_blog.html). To discuss these topics with other interested parties, a Google discussion group has also been established and instructions for joining the group are also on the webpage. The intent of the Climate-Aquatics Blog and associated discussion group is to provide a means for the 4,381 (& growing) field biologists, hydrologists, anglers, students, managers, and researchers currently on this mailing list across North 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 will 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 I and my colleagues have been a part of in the Rocky Mountain region, but attempts will be made to present topics & tools in ways that highlight their broader, global relevance. Moreover, 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 will occur to facilitate the rapid dissemination of knowledge among those most concerned about climate change and its effects on aquatic ecosystems.

If you know of others interested in climate change and aquatic ecosystems, please forward this message and their names can be added to the mailing list for notification regarding additional science products on this topic. If you do not want to be contacted regarding future such notifications, please reply to that effect and you will be removed from this mailing list.

Previous Posts

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

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

Future topics…
Climate-Aquatics Management Module