Climate-Aquatics Blog #41:
Part 1, Mechanisms of change in fish populations: Patterns in common trend monitoring data

Are we sitting on some of the answers?

Hi Everyone,
So this time we're going to start a new mini-module looking at the various mechanisms by which fish populations may adjust to climate change. After all, those big distributional changes & fish-sky falling scenarios projected for this century (Blog #33) must ultimately be rooted in myriad smaller scale processes that we'll need to understand to make accurate predictions. As we take this next step, the potential exists for big synergies to occur between much of what we already know about fish populations at relatively limited spatial and temporal scales and the meso-scale models that downscale climate change effects to stream temperature (Blogs #7, #40) and hydrology (Blog #20). As we make this next set of linkages, we'll be putting the final pieces in place to create a system for translating the global to the local (graphic 1).

But how to accomplish this linkage? Here, it may be useful to re-examine & expand the traditional view of population dynamics and their relationship to environmental relationships. In the traditional view (at least to my simple brain), a population's size, it's inter-generational growth rate (lambda), and long-term persistence probability is determined by the sum of the BIDE processes (birth + death + emigration + immigration). Each of those processes is, in turn, related to the environment as dictated by the size, quality, distribution, and temporal variability of suitable habitats. And that last bit—temporal variability—is key, because anyone that hunts, fishes, or otherwise closely tracks population abundances in their favorite haunts knows there are good years (lots of juvenile recruitment and growth) and bad years (not much of either) for populations. Get a string of consecutive good years and there seem to be critters everywhere, or consecutive bad years and they're nowhere.

So the temporal variability of habitat conditions at a site needs to mesh with a species biology & life cycle requirements for things to work. Habitats where these things come together consistently tend to support larger, or more productive, populations; habitats where things mesh poorly tend to have smaller or less productive populations. Moreover, climate, as manifest by short- (intra- and interannual) and long-term (decadal and century) variability in stream temperature and flow conditions, is a ubiquitous & strong determinant of temporal variation in habitat conditions, so we'd expect to see relationships with the BIDE processes if we look closely.

A nice paper that articulates these concepts more coherently than I is Jackson and colleagues (Available here: http://www.cakex.org/sites/default/files/PNAS.pdf) titled "Ecology & the rachet of events, climate variability, niche dimensions, and species distributions" I think "rachet" is a perfect term for thinking about the incremental changes that occur through time as climate bounces around and population dynamics adjust accordingly (graphic 2). Another good one is Glenn and colleagues (attached) that uses time-series monitoring data for owl populations to examine the effects of short-term climatic variation on population parameters like lambda, survival, and recruitment.

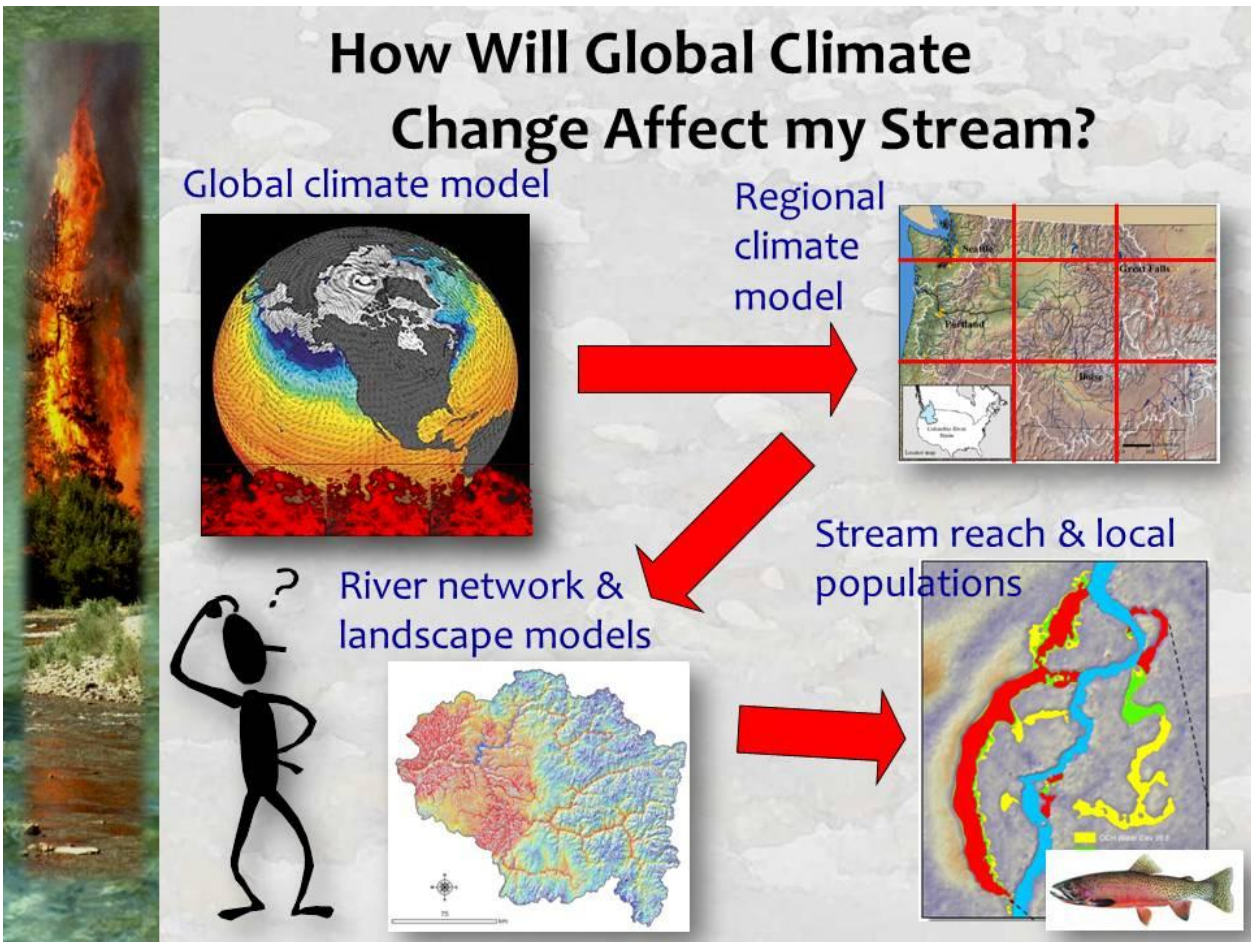
And if it's the case that useful information regarding bioclimatic linkages can be extracted from time-series monitoring data, then we are indeed sitting on a goldmine from whence a better understanding of climate effects on fishes may be developed because there are many, many sites where annual abundance & species composition monitoring has been done for years. As fishy illustration of this fact, we'll highlight two examples by our European colleagues. In the first study by Clews and colleagues (attached), monitoring data on the density of brown trout and Atlantic salmon across the Welsh River Wye were compiled over a 20 year period. The authors then described relationships between the abundance of juveniles and a suite of the prior year's climatic conditions (graphic 3). Generally speaking, juvenile abundances were higher when the preceding year's climate was cool & wet, and abundances were lower when it was warm and dry. That being the case, one could surmise that if climate projections for the River Wye indicate warmer/drier summers will become more common in 50 years, then these species will fare poorly. Although more years of biological monitoring data are always good, an attractive feature of this approach is that it doesn't require decades of data to yield useful results. As few as several years (i.e., 4 - 5) of monitoring might be sufficient to provide insights regarding future population sensitivity if those years encompassed a wide range of climatic conditions.

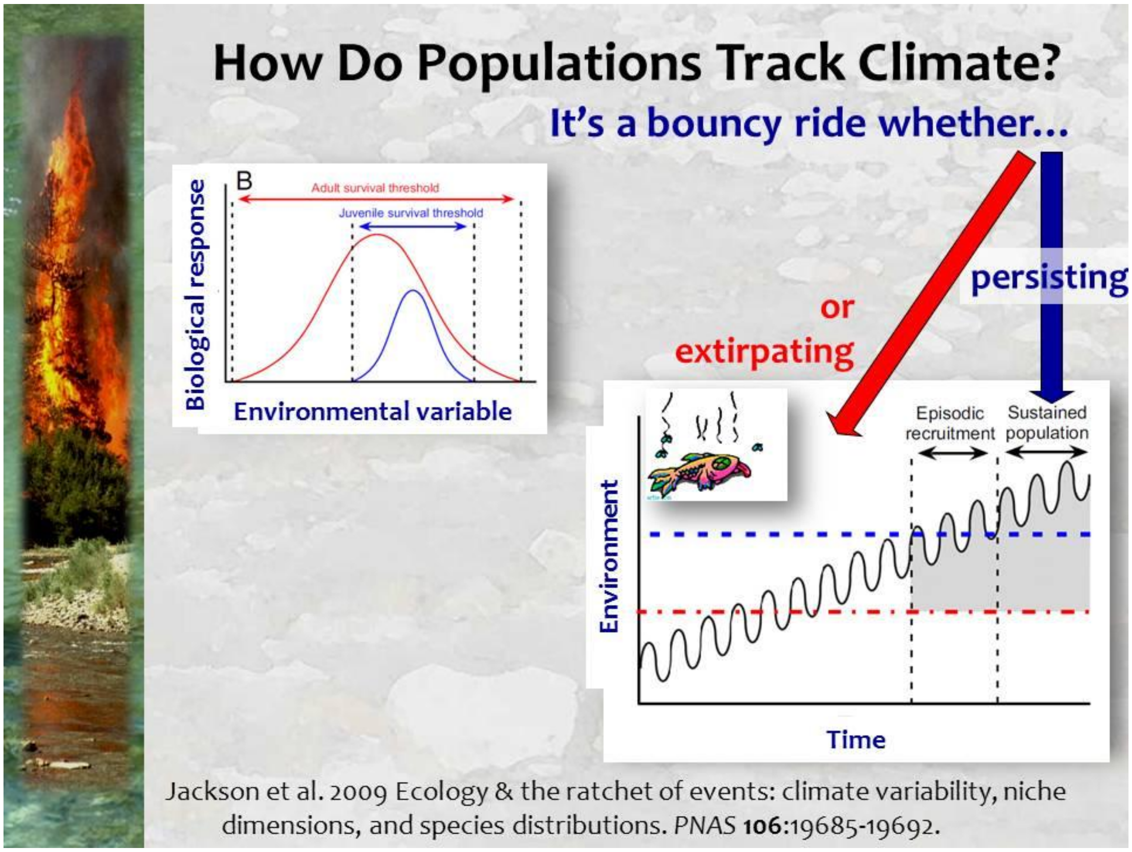
In the second fishy example, Almodovar and colleagues (attached) estimated the abundance of brown trout within 19 reaches each year during a 12 year period from 1993-2004 in northern Spain (graphic 4). Concomitant with a long-term warming trend across the region, an overall decline in the abundance of brown trout was observed. There was important spatial variation in this trend, however. Populations in reaches at the lowest elevations and warmest temperatures declined rapidly whereas those at high elevations and cold temperatures showed no trend. Thus, the monitoring data from cold streams served as an experimental control, and the study provides nice empirical support for the general response pattern we'd expect in populations of ectothermic organisms arrayed along a temperature gradient subject to climate warming. There are several other aspects to this comprehensive study that are worth checking out, including some evidence of warm-water species expanding their distributions upstream, use of the brown trout data to validate a bioclimatic model that is subsequently used to make future projections, and means of assessing and discounting potential confounding factors like changes in angler pressure or habitat quality unrelated to temperature. It's worth a detailed read.

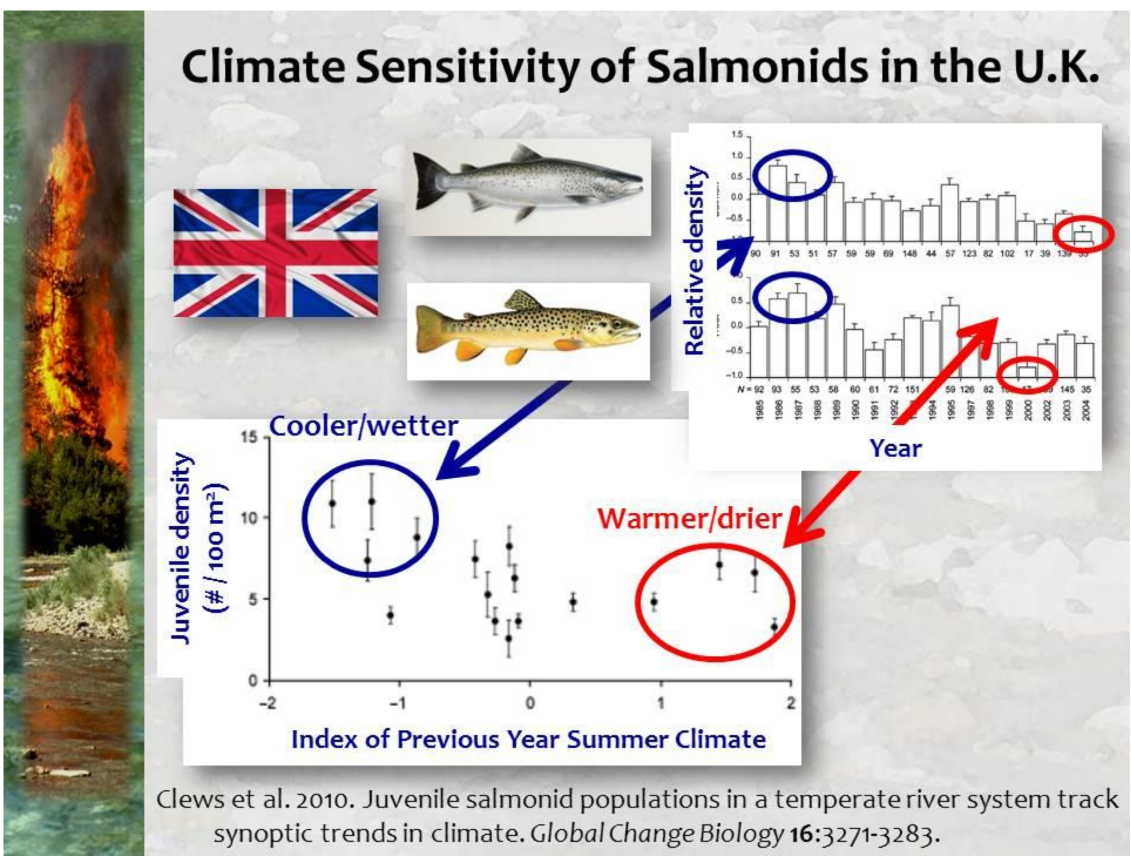
So that's it for now. In several subsequent blogs we'll continue this theme working through the various means by which climate change may affect local habitat conditions and patterns and processes in fish populations. Once we've forged that last link in our global fish system, we'll be ready to start the penultimate Climate-Aquatics management module.

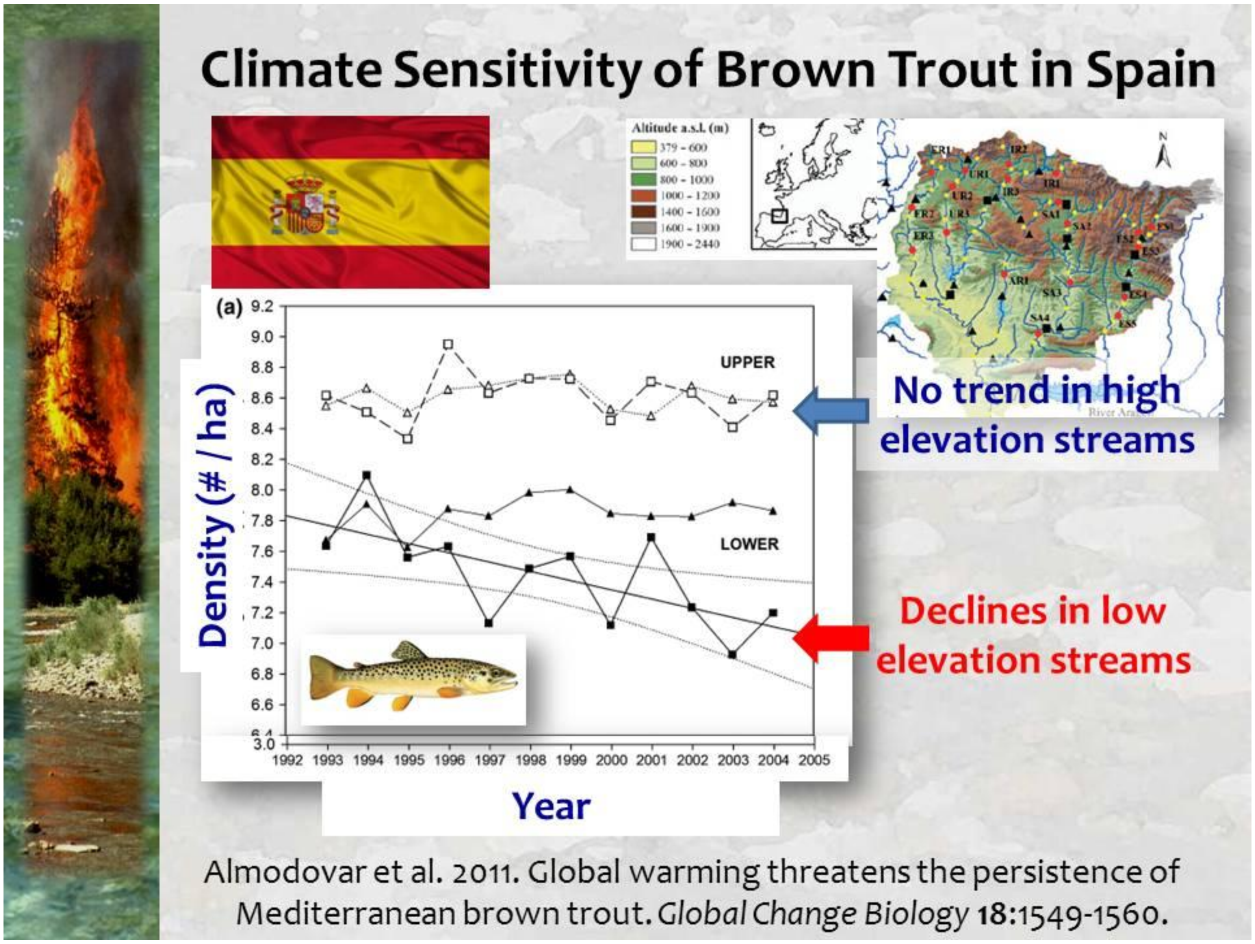
Until next time, best regards,

Dan




How Do Populations Track Climate?
It's a bouncy ride whether…
persisting
or
extirpating
B
Adult survival threshold
Juvenile survival threshold
Biological response
Environmental variable
Episodic recruitment
Sustained population
Environment
Time
Jackson et al. 2009 Ecology & the ratchet of events: climate variability, niche dimensions, and species distributions. PNAS 106:19685-19692.


Climate Sensitivity of Salmonids in the U.K.
Relative density
Year
Cooler/wetter
Warmer/drier
Juvenile density (# / 100 m²)
Index of Previous Year Summer Climate
Clews et al. 2010. Juvenile salmonid populations in a temperate river system track synoptic trends in climate. Global Change Biology 16:3271-3283.



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 4,853 (& 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
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

Future topics…

Climate-Aquatics Management Module