Climate-Aquatics Blog #49:
Part 8, Mechanisms of change in fish populations: Non-native species invasions

There's a war going on out there…

Hi Everyone,
As if there weren't enough complexities already in figuring out how BIDE processes in many native fish populations will adjust to climate-induced changes in the physical (Blog #41) and food environments (Blog #48), what if these populations also had to contend with alien invaders? Not the sort from space, but the sort that humans, both intentionally & unintentionally, have long been moving around the planet. In the literature, these are now usually referred to as non-native invasive species and we're presently in the middle of a global invasion pandemic. Once a non-native species is established in a stream or lake, there are many pathways, both direct and indirect, by which the local ecosystem can be affected (graphic 1; Cucherousset and Olden provide a good review hyperlinked here: http://depts.washington.edu/oldenlab/wordpress/wp-content/uploads/2013/03/Fisheries_2011c_Inv.pdf). Not all are negative, or even noticeable, but many are and it can be a real bugger to control or eliminate an invasive species when they are problematic.

Human mediated species invasions have no doubt been happening for 10,000s of years, back to when our species first dispersed out of Africa to colonize other parts of the Earth & brought along a few favorite critters & pesky tag-alongs. But in recent times these invasions have accelerated to where they're now orders of magnitude more common that was previously the case. The emergence of a global, hyper-connected economy means that humans and our goods move around so much that there are endless opportunities for invasive tag-alongs to make it into new environments. In fact, some now talk of a new Pangaea—reference to the supercontinent 200 million years ago when the land mass of the 7 continents was merged into one and species could more easily disperse across broad areas.

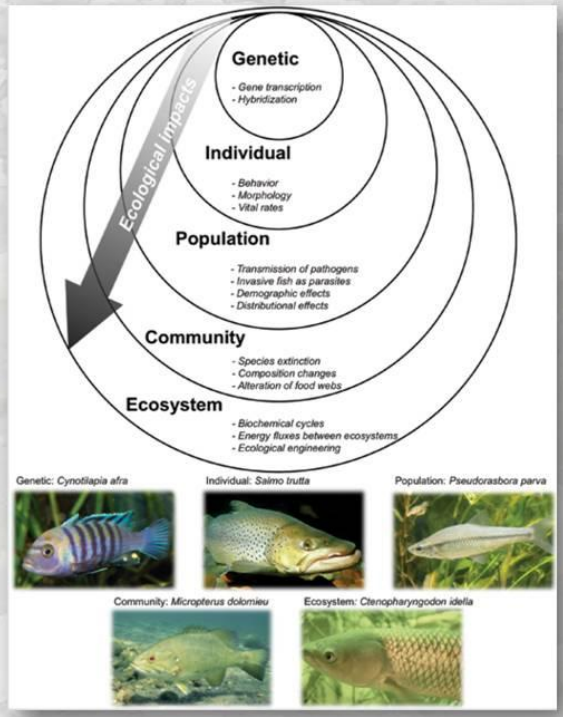
Compounding the pandemic of panmixing in the putative Pangaea is the possibility that environmental trends associated with climate change will facilitate the expansion of many invasive species into areas that were not previously suitable habitats (graphic 2; Rahel and Olden provide a good review hyperlinked here: http://www.uwyo.edu/frahel/pdfs/rahel-2008-1.pdf). Perhaps the best examples of this were the fishes comprising the first big wave of invasives (what we'll call the 'old-invasives') that were purposely trucked around from the late-1800's to mid-1900's, often to supplement existing fisheries or develop new ones. Some of the old-invasives have been parts of riverscapes long enough that they'd likely expanded to reach a quasi-equilibrium with their environmental niche. But just as distributions of native fishes are shifting in response to climate change (blog #'s 32, 34, 35, 42), the old-invasives are likely to be on the march in places where climatic constraints were previously limiting. Only this time, unfortunately, their like will be accompanied by a legion of new-invasive species that our species is spreading willy-nilly across the Earth.

It all portends a sort of global fish gladiator contest this century in which many native fishes, and even the old-invasives we've grown accustomed to, are going to have to vie & compete for survival in the new Pangaea. Understanding how and where it all goes, and what we can do about it is going to be a huge, costly, and ongoing challenge. Some monetary estimates already put the disruptions caused by non-native species at many millions & billions of $'s annually. And in some places, invasive fishes are so prevalent that they're directly impacting humans (graphic 3). Witness this video of the hazards that high flying invasive fish can cause your health (http://www.youtube.com/watch?v=rPeg1tbBt0A). A war of the worlds indeed.

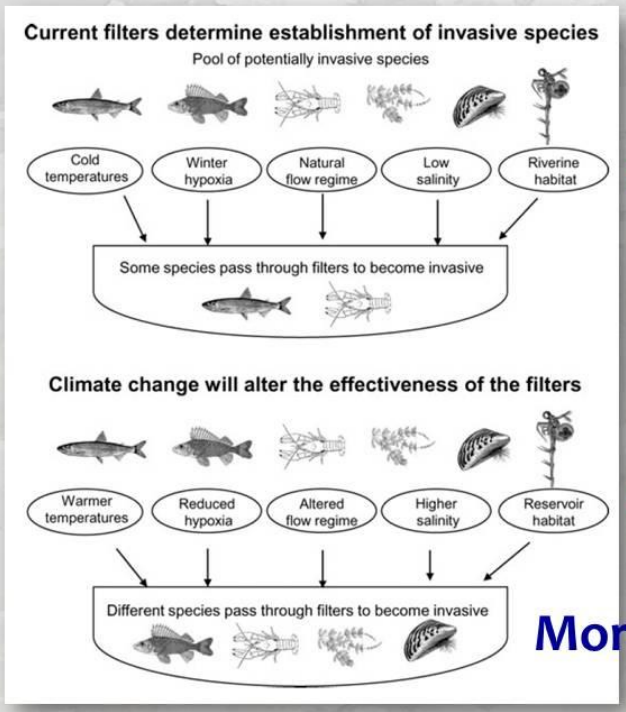
Until next time, best regards,
Dan

Now Tweeting at Dan Isaak@DanIsaak

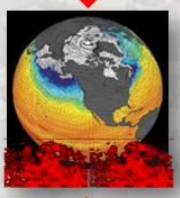
Ecological impacts of non-native species invasions are complex and may propagate across multiple levels of biological organization



Cucherousset & Olden. 2011. Ecological impacts of nonnative freshwater fishes. *Fisheries* **36**:215-230.



Old species filters



New filters

More invaders?

Rahel & Olden. 2008. Assessing the effects of climate change on aquatic invasive species. *Conservation Biology* **22**:521-533.

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 5,510 (& 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 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 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.

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

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

Future topics…

Climate-Aquatics Management Module

Climate-Aquatics End Game