Climate-Aquatics Blog #38: Part 2, Monitoring to detect climate effects on fish: Resurveys of historical stream transects

A "work-around" solution to time travel…

Hi Everyone,
So if only we could, like the protagonist in H.G. Wells classic 1895 book, *The Time Machine*, build a machine to travel back several decades and survey fish populations along stream transects to establish baselines for contemporary climate change assessments, then we'd be in business. But as of yet, time-travel has proven to be insoluble except in Hollywood & perhaps Einstein-ian physics, so we need a less expensive "work-around". (As an aside, if you haven't seen the 1960 movie adaptation of Well's book, I highly recommend it http://www.imdb.com/title/tt0054387/. Special effects are corny by today's standards but they were pretty fancy for the times and the story's a timeless one, but I digress…). A much easier, yet effective solution to time travel is simply resampling species occurrence along transects that were first sampled at least several decades ago. Based on the power calculations for stream isotherm shifts from last time (blog #37), that should ensure enough time has elapsed that distribution shifts related to climate change could occur. The attached study by Moritz & colleagues (graphic 1), where Grinnell's Yosemite transect from 100 years ago was resampled to document shifts in mammal distributions, is an excellent example. Although it's not a stream study, the premise is the same. Survey species occurrence along an elevational transect, use statistical techniques to estimate the boundaries of species distributions, and compare the locations of those boundaries between surveys.

Simple enough, and streams, by their linear nature, have lent themselves to transect surveys, so dozens, if not hundreds, of these surveys have been done previously (graphic 2). These streams are now prime candidates for resurvey efforts and I suspect contain the evidence needed to link climate warming to fish distribution shifts. That said, there are potentially confounding factors that will often interfere or synergize with climate trends. A good example is provided by a recent study by Hitt and Roberts (attached) wherein the authors resurveyed Burton & Odum's Virginia stream transects from ~69 years ago (graphic 3). At many sites, the authors found significant alterations of historical fish communities associated with species invasions and habitat

alterations, with communities in downstream reaches most affected. Although Hitt & Roberts is not a climate change study *per se*, the warming effect is probably there mixed up with everything else given that air temperature across the state have been warming rapidly (http://www.climatecentral.org/news/the-heat-is-on/).

It will not be uncommon for confounding factors to occur, so isolating the effects of warming will take careful study but there are ways. One option is simply to avoid streams with confounding factors and focus on resurveys of native fishes in "pristine" streams not being invaded by non-natives. That's often easier said than done in many areas these days, but there are instances, especially in mountain streams where the upstream extent of species distributions are delimited by cold temperatures, habitats are in excellent condition, and invasive species absent, where it is possible. Another option is to amp up the statistical power to detect trends by increasing sample size, which would allow the relative effects of habitat degradation, invasive species, and temperature increases to be estimated. So rather than resurveying 1 or 2 streams, we resurvey dozens or perhaps a few hundred where the best historical baselines exist (graphic 4). Remember, we're already doing thousands of stream electrofishing rodeos each year (blog #30), so targeting even a tiny proportion of these rodeos to resurveys wouldn't require much in the way of additional resources—only a bit of time to compile the historical site information into a digital database and some time to coordinate resurvey efforts within and among agencies. Dirt cheap, given the wealth of new information we'd learn from developing and formalizing such networks of "sentinel streams." This concept isn't exactly new, having been around for many years in the arena of long-term ecological research but the time is now ripe in the fish world given what we need to learn in a hurry. The attached paper by Craine & colleagues calls these coordinated networks EDENs for "Environmentally Distributed Ecological Networks" and covers some of their general in's and out's.

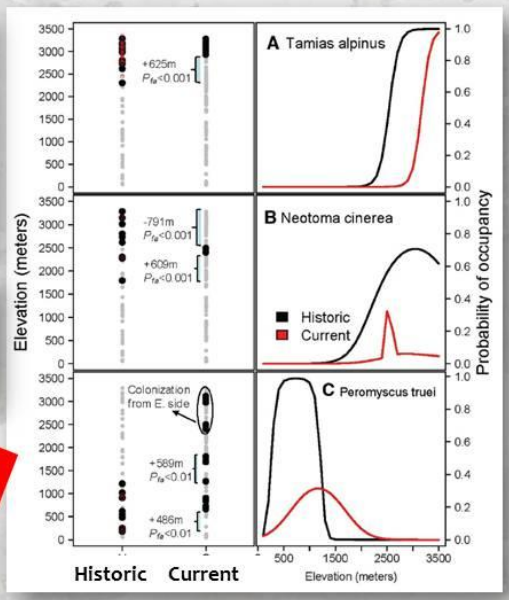
So that's it for now. Next time out, we'll examine a few additional ways of deriving estimates of distribution shifts from commonly available datasets. These will involve something called "BIG DATA", which is intimately linked to "Crowd-Sourcing"—a couple of terms and powerful techniques we'll need familiarity with as we work to unlock the time capsules that many historical datasets ultimately represent.

More on that later,
Dan

Resurvey of Grinnell's Famous Yosemite Transect From 100 Years Ago...

Elevation

Distance



Moritz et al. 2008. Impact of a century of climate change on small-mammal communities in Yosemite National Park, USA. *Science* **322**:261-264.

Many Stream Transect Studies Exist That Could be Resurveyed

ALTITUDINAL DISTRIBUTION OF BROWN TROUT AND OTHER FISHES IN A HEADWATER TRIBUTARY OF THE SOUTH PLATTE RIVER, COLORADO

ROBERT E. VINCENT AND WILLIAM H. MILLER[1]

Colorado Cooperative Fishery Unit, Colorado State University, Fort Collins, Colorado 80521

(MS received August 9, 1968; accepted March 10, 1969)

Fish Assemblages and Habitat Gradients in a Rocky Mountain–Great Plains Stream: Biotic Zonation and Additive Patterns of Community Change

FRANK J. RAHEL

Department of Zoology and Physiology, University of Wyoming Laramie, Wyoming 82071, USA

WAYNE A. HUBERT

Transactions of the American Fisheries Society 120:319–332, 1991

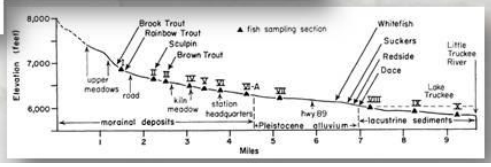
Species	Site number and elevation (m) 1 2,234	2 2,030	3 2,015	4 1,591	5 1,559	6 1,524	7 1,510	8 1,490	9 1,470	10 1,423
Upstream species										
(1) Brook trout	100	79	72	6						
(2) Brown trout		21	24	+	+	+			2	
Species showing an additive pattern										
(1) White sucker				4	42	34	13	26	51	35	39
(2) Longnose dace					23	18	52	6		33	12
(3) Longnose sucker					2	19	12	13	1	1	2
(4) Creek chub					27	27	20	6	47	28	24
(5) Sand shiner							1	12	+		14
(6) Bigmouth shiner								6	+		4
(7) Fathead minnow								8			+
(8) Common shiner											4
(9) Brassy minnow											+

DISTRIBUTION AND ABUNDANCE OF FISHES IN SAGEHEN CREEK, CALIFORNIA

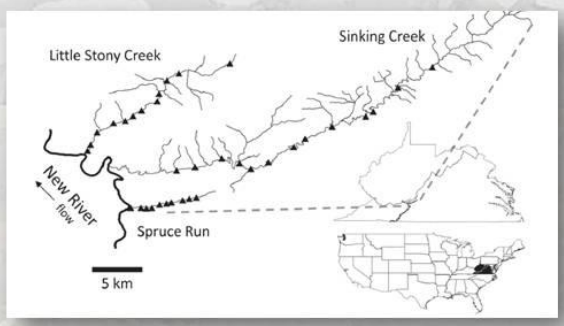
RICHARD GARD, School of Forestry and Conservation, University of California, Berkeley 94720[1]

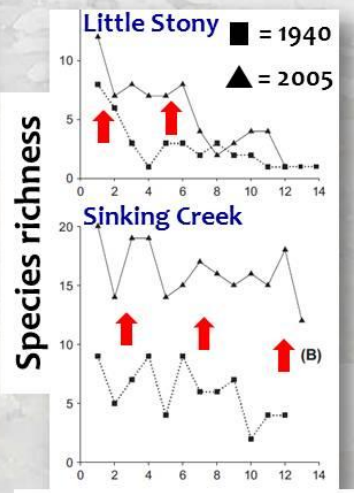
GLENN A. FLITTNER, Bureau of Marine Sciences, California State University, San Diego 92100

J. Wildl. Manage. 38(2):1974



Resurvey of Burton & Odum's Stream Transects from 69 years ago...





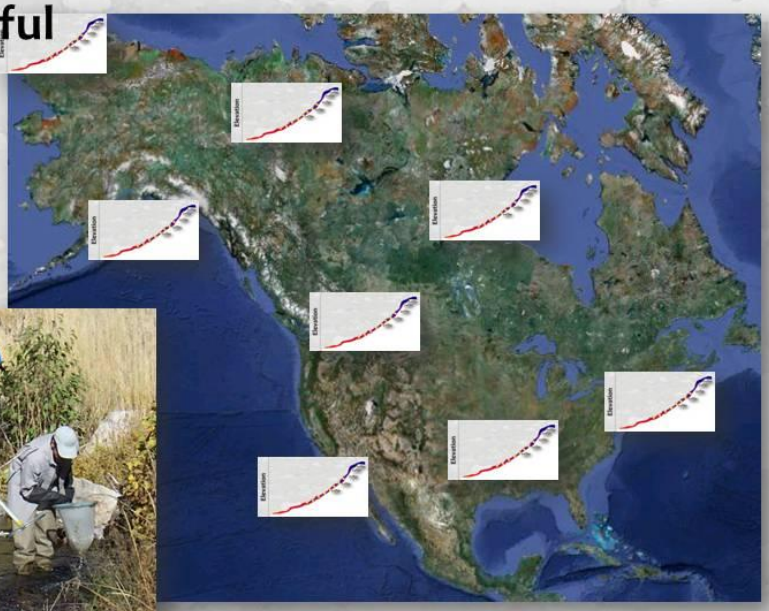


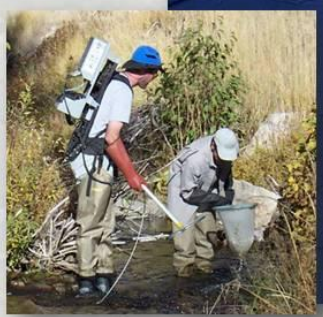



March of the fishes...

Hitt & Roberts. 2011. Hierarchical spatial structure of stream fish colonization and extinction. *Oikos* **121**:127-137.

Coordinated Networks of "Sentinel" Streams Periodically Resurveyed Would be Powerful





Craine et al. 2007. Building EDENs: The rise of environmentally distributed ecological networks. *BioScience* **57**:45-54.

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 4,538 (& 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
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

Future topics…
Climate-Aquatics Management Module