NC1189 manuscript conference calls: 9/20/18 and 9/27/18

NC1189 manuscript conference call: 9/2018

- Welcome
- Thank you
    - It's been a long road
- Manuscript status
- Comments or questions from the team
    - Climate change – when managers read the abstract, they may be turned off regarding the prospects of making meaningful progress re: climate change
        - Mike K – how much they can address climate change directly (not always directly), emphasis on adaptation/mitigation – positive outcome but realistic (active planning and preparing for the future)
        - Dennis D (see his email) – managers have to deal with short-term, day-to-day management issues, chiefs say "I can't deal with that ... can only respond amid 15 short-term problems";
            - Don't accuse ppl of not working ... BUT rather say that resources need to be allocated at higher levels ... within the constraints of current budgets, managers are restricted to short-term projects ... need a shift from the TOP
            - Bring in Extension ... use univs. And Expt stations to come up with creative ways to make climate change in the interest of agencies
            - Bill T – and role of NGOs (but caution on some NGOs that aren't science-driven, too extreme ... Dennis Devries)
        - Dana I – AES directors have great capacity to tap into Extension programs, engage the public, richer university-agency collab (AES-profs) ... tapping into AES directors as a mechanism to address climate change (and thereby reach agencies and the public)
        - Mazeika S – climate change is so diffuse (temp, spatially), need long-term and "large-space" views (watersheds to regions), partnerships over broader spatial scales ... highlight interactions between climate ch and other stressors – to bring climate change to the fore (direct and indirect resource allocation – two birds with one stone)
            - Suzanne G – tweak wording to emphasize INTERACTIONS
            - "We have multiple stressors, but CC and invs species as focal ... and compared to others" ..."mult stressors with an initial focus on CC and invs. Spp." (end of Introd)
        - Paul V – initial framing, wanted to look at climate change broadly – how did it evolve into multi-stressor?
            - Mike K – advantage of multi-issue approach is comparative ranking of CC and inv spp against other stressors ... started as a focus on CC and Inv. Spp, true value from a larger lens (new text in the Summary)
- Time frame for final revision and submission to Fisheries
- Other questions, comments, or concerns?

NC1189 manuscript conference call: 9/27/18

- Paper changes
- Time frame for final revision and submission to Fisheries
- Other questions, comments, or concerns?
- Next steps as an NC1189 group
    - Mike K: Continue with surveys (of researchers in agencies, AES, univ. prof)
    - Mazeika: Leveraging what we've done to apply for a CHANS NSF grant (CHN?) ... or similar program
    - Dennis: characterizing national diversity of agency-AES-univ. interactions (across U.S.) .. how their interactions transpire through the land grant system
- Annual mtg (hard to find time when all/lots can meet)
    - Dennis: can't make early Aug. mtgs. ... how about early summer? May?
    - Anne: but quarter system folks would have to meet in mid-June (not May, school in session)
    - Suzanne: mid to end Aug. works well
    - Confirm with Kyle Hartman if WVU is still available to host?

Mike K – suggestions for paper

- Add acknowledgments, COPY OF SURVEY
- Are AES ppl interacting with admins – use admin responses to verify AES response, vice versa (see data) ...not enough data, only one state where AES and admin responded, etc.
- # employees – 1-5 as "low" (present as low ... lowest part of our scale) ... and example of higher, too
- Don't say ppl aren't cultivating partnerships ... use "continue" (non-accusatory) ... if funding doesn't come from higher levels, these "other partnerships" could divide the labor to "pick up the slack" ... impt ROLES that others can play (e.g., addressing diffuse problems)

Melissa – suggestions for paper

- Less prescriptive where "need" is used (pick a less prescriptive word)

Mazeika – suggestions for paper

- Stronger language at end of ABSTRACT, and end of paper (line 557)... ("we call for an integrated framework ...") ... "we call for .."
- Change degradation to "impairment"

Anne – suggestions for paper

- "Climate change stressors" – variability within this term (e.g., water temperature increase, precipitation change, saltwater intrusion) ... future surveys could separate the specific stressors assoc. with climate chg.

SAES-422

Multistate Research Activity Accomplishments Report (Annual)

Project/Activity Number: NC1189

Project/Activity Title: Understanding the Ecological and Social Constraints to Achieving Sustainable Fisheries Resource Policy and Management

Period Covered: October 1, 2017-September 30, 2018

Date of This Report: October 1, 2018

Annual Meeting Date(s): Conference calls (September 20, 2018; September 27, 2018) and an informal gathering at American Fisheries Society conference (August 19, 2018). Annual meeting to be hosted in May 2019.

Participants: Taylor, William (taylorw@msu.edu) - Michigan State University; Carlson, Andrew (carls422@msu.edu) - Michigan State University; Hartman, Kyle (hartman@wvu.edu) - West Virginia University; DeVries, Dennis (devridr@auburn.edu) - Auburn University; Harrell, Reginal (rharrell@umd.edu) - University of Maryland; Infante, Dana (infanted@msu.edu) - Michigan State University; Venturelli, Paul (paventurelli@bsu.edu) - Ball State University; Melstrom, Max (rmelstrom@luc.edu) - Loyola University Chicago; Wuellner, Melissa (wuellnermr@unk.edu) - University of Nebraska Kearney; Kinnison, Michael (mkinnison@maine.edu) - University of Maine; Sullivan, Mažeika (sullivan.191@osu.edu) - Ohio State University; Weber, Michael (mjw@iastate.edu) - Iowa State University; Newman, Raymond (newma004@umn.edu) -University of Minnesota; Zydlewski, Gayle (gayle.zydlewski@maine.edu) - University of Maine; Gray, Suzanne (gray.1030@osu.edu) - Ohio State University; Pegg, Mark (mpegg2@unl.edu) - University of Nebraska-Lincoln; Todgham, Anne (todgham@ucdavis.edu) - University of California-Davis

Brief summary of minutes of annual meeting: See attached meeting minutes.

Accomplishments:

Short-term Outcomes: Described below in Outputs and Activities.

Outputs

Project activities have resulted in a variety of outputs, as described in the following bullet points.

- We created a collaborative, coupled human and natural systems research framework to evaluate the effects of climate change and invasive species in freshwater ecosystems in a manner that promotes the purpose of the Hatch Act to conduct agricultural research, including fish production in wild fisheries and captive operations.
- We analyzed results from surveys distributed to U.S. fisheries administrators (i.e., chiefs) and Agricultural Experiment Station directors regarding their perceptions of the impacts

of climate change and invasive species on freshwater ecosystems in their respective states.

- We summarized results of these surveys in a manuscript that is currently under review in the peer-reviewed journal *Fisheries*.
- We developed stream-specific and regional models of climate change and its effects on growth and survival of stream trout (i.e., brook trout, brown trout, rainbow trout), publishing this research in multiple peer-reviewed manuscripts resulting from NC1189-wide collaborative interactions.
- We partnered with Michigan fisheries professionals to produce a decision-support tool that they can use to manage trout streams amid climatic changes within and beyond Michigan.

Activities

Pursuant to Milestone 1 (described below), we created a coupled human and natural systems research framework to evaluate the effects of climate change and invasive species in freshwater ecosystems in a manner that promotes the purpose of the Hatch Act to conduct agricultural research. For example, climate change effects on fisheries include changes that operate indirectly through land use factors (e.g., hydrology, soil conservation), leading to important linkages between climate, agricultural land use, and fisheries productivity. In effect, our research on how climate-induced changes to water quantity and quality affect fisheries has implications for agriculture and agricultural practices in watersheds. Similarly, invasive species impact valued native fish populations by affecting nutrient dynamics in aquatic systems, exacerbating the effects of agricultural runoff, or by altering stocking program decisions for hatchery-raised fish (i.e., 'public aquaculture'). Our research was centered around improving knowledge of these linkages, which provided valuable science in support of sustainable agriculture and fisheries/aquaculture management.

We surveyed state fisheries chiefs and Agricultural Experiment Station directors regarding the effects of climate change and invasive species on freshwater ecosystems. We asked fisheries administrators and AES directors to evaluate their state's fisheries from various perspectives (e.g., ecological, economic) and rate the importance of various threats to aquatic ecosystems, with particular emphasis on climate change and invasive species. We summarizdd survey results and conclusions in a manuscript that is currently under review in the peer-reviewed journal *Fisheries*.

We also measured the accuracy of stream-specific air-water temperature regression models by backcasting Michigan stream temperatures in 2006 and 2012, years with pre-existing air and stream temperature metrics. Then, we forecasted stream temperatures in 2036 and 2056 and projected thermal habitat suitability for brook charr, brown trout, and rainbow trout growth and survival. Stream-specific models accurately projected stream temperature and thermal habitat suitability for growth and survival of brook charr, brown trout, and rainbow trout. Under multiple scenarios of projected climate change, stream-specific models predicted thermal habitat

status with 93.0% percent overall accuracy in streams with brook charr (94.0% accuracy), species has a wider temperature range for growth (12.0-22.5°C) compared to brook charr (11.0-20.5°C) and brown trout (12.0-20.0°C). As baseflow index (i.e., relative groundwater input) increased, stream thermal sensitivity (i.e., relative susceptibility to temperature change) decreased. Thus, the magnitude of temperature warming and frequency of thermal habitat degradation were lowest in streams with the highest baseflow indices. We used conference calls to consistently discuss stream temperature modeling methods, results, and conclusions as an NC1189 group, which allowed for cross-pollination of ideas across states and facilitated management-relevant research across the geographic area encompassed by our NC1189 partners.

Also pursuant to Milestone 1, we compared the accuracy of stream-specific and generalized (region-specific) temperature models in groundwater-dominated and surface runoff-dominated streams in Michigan. Despite their lower accuracy in predicting exact stream temperatures, generalized models accurately projected salmonid thermal habitat suitability in 82% of groundwater-dominated streams, including those with brook charr (80% accuracy), brown trout (89%), and rainbow trout (75%). In contrast, generalized models predicted thermal habitat suitability in runoff-dominated streams with much lower accuracy (54%). These results suggest that, amid climate change and constraints in resource availability, generalized models are appropriate to forecast thermal conditions in groundwater-dominated streams and inform regional-level salmonid management strategies that are practical for coldwater fisheries managers and other stakeholders. We recommend fisheries professionals reserve resource-intensive stream-specific models for runoff-dominated systems containing high-priority fisheries resources (e.g. trophy individuals) that will be directly impacted by projected stream warming. Overall, our research promotes resilience-based salmonid management by providing a methodology for stream temperature and thermal habitat suitability prediction. Fisheries professionals can use this approach to protect coldwater habitats and drivers of stream cooling and ultimately conserve resilient salmonid populations amidst forecasted changes in climate and land-use.

Pursuant to Milestone 2, we analyzed results from our survey of fisheries chiefs in the United States regarding their perceptions of the impacts of climate change and invasive species on inland fisheries and aquatic resources. We summarized this research in a manuscript that is currently under review in the peer-reviewed journal *Fisheries*. We wrote the manuscript as an NC1189 group, with teams of researchers assigned to particular sections of the paper. This necessitated numerous conference calls in which we discussed survey data analysis, results, and conclusions and ultimately developed recommendations for resilience-based fisheries management. We also collaborated with Michigan fisheries professionals to produce a decision-support tool to facilitate management decision-making in 52 trout streams amid climatic changes. To gather necessary information for the decision-support tool, we designed a 30-question survey instrument to evaluate the opinions and perspectives of Michigan fisheries professionals regarding the ecological, environmental, and socioeconomic aspects of trout management. The survey was approved by the Michigan State University Institutional Review Board and delivered to 40 Michigan Department of Natural Resources (MDNR) fisheries professionals (23% of fisheries staff) via SurveyMonkey, with reminder emails sent every three

weeks during a 2.5-month time span from November 2016 to February 2017 in which the survey was open. The decision-support tool ranked trout streams based on manager-defined stream criteria (e.g., current and projected 2056 temperature, groundwater contribution, trout abundance, watershed land cover), enabling fisheries professionals to make ecologically, socioeconomically robust management decisions that promote thermally resilient streams and trout populations. Stream ranking using all criteria indicated that certain recreationally significant fisheries (e.g., Muskegon River) will experience warming that may cause them to become less important for trout management. However, lesser-known fisheries (e.g., Davenport Creek) were projected to become more thermally suitable and important for trout management. With this information available, managers can anticipate future thermal, hydrological, and biological conditions in streams and thereby make informed, resilience-based management decisions to sustain trout fisheries in a changing climate. As with all of our work as an NC1189 group, we consistently discussed our research via conference calls, which allowed us to compare our ideas among states ultimately design scientific investigations that are broadly informative for fisheries management.

Pursuant to Milestone 3, we wrote and recently submitted a manuscript based on our survey of United States fisheries chiefs regarding the effects of climate change and invasive species on inland fisheries and aquatic resources. This manuscript, now under review in the peer-reviewed journal *Fisheries*, helped us address Goal 3 of this project. For instance, we designed the survey so that the responses of fisheries chiefs provided direct information on the socioeconomic and environmental factors involved in individual and organizational responses to climate change and invasive species. In turn, knowledge of how fisheries chiefs (and the organizations they represent) make decisions to mitigate these stressors improved our ability to develop effective approaches for inland fisheries and aquatic resource management. In addition, our survey of Michigan fisheries professionals regarding trout management in a changing climate (see description above) enabled us to evaluate the socioeconomic and environmental factors that influence the ways in which individuals and organizations respond to climate change in Michigan. Like the survey of fisheries chiefs throughout the United States, responses to the Michigan survey allowed us to understand individual and organizational strategies for addressing climate change and ultimately enhance inland fisheries and aquatic resource management in a changing climate.

Milestones

Milestones that encapsulate all of the project's short-term outcomes, outputs, and activities were:

- Foster a collaborative, coupled human and natural systems research framework to assess the ecological and socioeconomic effects of climate change and invasive species on the productivity of inland fisheries and aquatic resources.
- Analyze the ecological, environmental and socioeconomic factors which mitigate or exacerbate the introduction, establishment, or effects of invasive species and climate change effects at multiple spatial and ecological scales.
- Determine the socioeconomic and environmental factors that influence the ways in which individuals and organizations respond to invasive species and climate change and the

likely consequences of those responses for effective inland fisheries and aquatic resource management.

Impacts

Impacts of the project are described in the following bullet points.

- All of the above research efforts have direct implications for development of management strategies. Information from these projects has been presented to the funding agencies, along with recommendations for potential application of these finding via management plans.
- Fisheries and aquatic resource professionals can use our coupled human and natural systems research framework to evaluate the effects of climate change and invasive species in freshwater ecosystems.
- Natural resource professionals will benefit from our research as communicated in a written manuscript (under review in *Fisheries*), which specifies mechanisms for addressing long-term, socio-ecologically critical management issues (e.g., climate change) while recognizing budgetary constraints.
- Fisheries and aquatic resource professionals can use our stream-specific water temperature modeling approach to forecast water temperatures in trout streams and thereby manage thermal habitats for resilience amid climate change.
- Fisheries and aquatic resource professionals will benefit from our assessment of the relative accuracy of stream-specific and generalized (region-specific) water temperature models. A published manuscript communicating this research makes it clear that amid climate change and constraints in resource availability, fisheries professionals can use generalized models to forecast thermal conditions in groundwater-dominated streams and inform regional-level trout management strategies. Moreover, they can reserve resource-intensive stream-specific models for runoff-dominated systems containing high-priority fisheries resources (e.g. trophy individuals) that will be directly impacted by climate change.
- Fisheries professionals and their partners in land management organizations can use our decision-support tool to inform thermal habitat management in coldwater streams affected by climate change. Specifically, managers can anticipate future thermal, hydrological, and biological conditions in coldwater streams and thereby make informed, resilience-based management decisions to sustain coldwater fisheries productivity in a changing climate.

Publications

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Carlson, A. K., W. W. Taylor, Z. Basher, T. D. Beard, Jr., D. M. Infante. 2018. Science to action: decision-support to advance stream trout management in a changing climate. Proceedings of the Wild Trout XII Symposium 12:85-92.

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