Meeting minutes, NC1189, 8/21/2017, meeting at AFS 2017

Attendees: Bill Taylor, Kyle Hartman, Reggie Harrell, Dennis Devries, Andrew Carlson

Additional NC1189 partners: Suzanne Gray, Dana Infante, Michael Kinnison, Max Melstrom, Ray Newman, Mark Pegg, Mazeika Sullivan, Anne Todgham, Paul Venturelli, Dave Wahl, Michael Weber, Melissa Wuellner, Gayle Zydlewski

- Fisheries administrator survey manuscript
    - All sections of the paper are written except for the Discussion
        - The Discussion group will use the survey summary and the current draft of the Results section to write the Discussion
        - Discussion group writers will start with key bullet points, expand them into full paragraphs
        - Discussion group writers are can add results from AES Director survey to the Discussion and compare them with fisheries administrator results (or AES Director survey findings can be included in the Results)
    - Considerations for writing the paper
        - Various state agencies have very different fisheries responsibilities and employee duties (e.g., hatchery duties seem to vary by state)
        - Regional approach acceptable by IRB?
            - Should be acceptable because MSU IRB approved the survey with the optional state question in it
            - Bill and Andrew can check to make sure a regional approach is acceptable
- Annual Meeting next year (2018) at West Virginia University
    - August may not work well
    - We can have it any time of year, so possibly explore other opportunities?
    - On campus (before students come back) or off campus (natural resource station)?
    - Focus on planning future projects (e.g., invasive species)?
- To do
    - Finish Discussion, blend sections together into a complete paper
    - Have a Skype call to talk about paper and next annual meeting
    - Use the paper (very timely) as leverage for future Hatch funding?
    - Add more NC1189 partners from other regions across the U.S. to broaden our reach and impact
    - Development of a synthesis project at the end of the multistate program that addresses the goals of NC1189

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, 2016-September 30, 2017

Date of This Report: October 1, 2018

Annual Meeting Date(s): August 21, 2017 (plus conference calls throughout the year: August 31, 2016; October 31, 2016; March 6, 2017; April 19, 2017)

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; NC1189 partners not present at meeting: 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 designed and distributed surveys 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 are currently analyzing results of these surveys and will compile them in a manuscript that will be submitted to 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 state agency 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 will summarize survey results and conclusions in a manuscript that will be submitted to 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 surveyed fisheries chiefs in the United States regarding their perceptions of the impacts of climate change and invasive species on inland fisheries and aquatic resources. This research will be summarized in a manuscript that will be submitted to the peer-reviewed journal *Fisheries*. 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 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 helped us address Goal 3 of this project and will eventually be submitted to the peer-reviewed journal *Fisheries*. 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 strategies for resilience-based fisheries and aquatic resource management. 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 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

Boyer, T. A., R. T. Melstrom, L. D. Sanders. 2017. Effects of climate variation and water levels on reservoir recreation. Lake and Reservoir Management 33:223-233.

Carlson, A. K., W. W. Taylor. 2017. In the footsteps of a heroine: honoring Janice Lee Fenske's fisheries legacy. Annual Meeting of the Michigan Chapter of the American Fisheries Society. Mackinaw City, Michigan. (Best Student Paper).

Carlson, A. K., W. W. Taylor, D. M. Infante. 2017. Accounting for groundwater and precipitation dynamics in stream temperature modeling to achieve resilient salmonid management in a changing climate. 147th Annual AFS Meeting, Tampa, Florida.

Carlson, A. K., W. W. Taylor, D. M. Infante. 2017. Going against the flow: modeling coldwater stream temperatures from above and below. 77th Annual Midwest Fish and Wildlife Conference. Lincoln, NE.

Carlson, A. K., W. W. Taylor, J. Liu, I. Orlic. 2017. The telecoupling framework: an integrative tool for enhanced fisheries management. Fisheries 42:395-397.

Carlson, A. K., W. W. Taylor, K. M. Hartikainen, D. M. Infante, T. D. Beard, Jr., A. J. Lynch. 2017. Comparing stream-specific to generalized temperature models to guide coldwater salmonid management in a changing climate. Reviews in Fish Biology and Fisheries 27:443-462.

Carlson, A. K., W. W. Taylor, K. M. Schlee, T. G. Zorn, D. M. Infante. 2017. Projected impacts of climate change on stream salmonids with implications for resilience-based management. Ecology of Freshwater Fish 26:190-204.

Carlson, A. K., W. W. Taylor, T. Douglas Beard, Jr., D. M. Infante. 2017. Stream science to action: a decision-support tool for salmonid thermal habitat management amidst climate change. 77th Annual Midwest Fish and Wildlife Conference. Lincoln, NE.

Carlson, A. K., W. W. Taylor, Z. Basher, T. D. Beard, Jr., D. M. Infante. 2017. Linking stream temperature modeling withdecision-support tools for resilience-based salmonid management in a changing climate. 147th Annual AFS Meeting, Tampa, Florida.

Carlson, A. K., W. W. Taylor, Z. Basher, T. D. Beard, Jr., D. M. Infante, T. G. Zorn. 2017. Integrating decision-support and stream temperature modeling for resilience-based salmonid management in a changing climate. Wild Trout Symposium XII. West Yellowstone, Montana.

Hartman, K.J. 2017. Bioenergetics of brown bullhead in a changing climate. Transactions of the American Fisheries Society 146:634-644.

Hartman, K. J., O. Jensen. 2017. Anticipating climate change impacts on Mongolian salmonids: bioenergetics models for lenok and Baikal grayling. Ecology of Freshwater Fish 26:383-396.

Kinnison, M. T, S. A. Carlson. 2017. An introduction to redefining Darwinian Fisheries. 147th Annual Meeting of the American Fisheries Society, Tampa, FL.

Pope, K. L., L. A. Powell, B. S. Harmon, M. A. Pegg, C.J. Chizinski. 2017. Estimating the number of recreational anglers for a given waterbody. Fisheries Research 191:69-75.

Siddons, S. F., Klein, G., N. P. Hogberg, M. A. Pegg. 2017. Borders and Barriers: Challenges of Fisheries Management and Conservation in Open Systems. River Research and Applications 33:578-585.

Spurgeon, J. J., M. A. Pegg. 2017. Fish growth and river flows: response of a non-fluvial specialist and applicability of current river production models. Freshwater Biology 62:291-302.

Taylor, W. W., M. Good, T. Scholze, A. K. Carlson, H. Triezenberg, B. Lambe. 2017. The changing face of recreational fisheries in the Laurentian Great Lakes and its ecological and

socio-economic consequences. 8th World Recreational Fishing Conference. Victoria, British Columbia.

Tuckett, Q. M., K. S. Simon, M. T. Kinnison. 2017. Cultural eutrophication mediates the context-dependent eco-evolutionary feedbacks of a fish invader. Copeia 105:483-493.