INDIANA-ILLINOIS SEA GRANT FINAL REPORT

Project Title: Land use disturbance impacts on stream fish physiology.

Principal Investigator(s) and Affiliation:
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OBJECTIVES:

Long Term: Provide the foundational information for future research to develop physiological techniques and tools for land use planners, and natural resources practitioners to predict and mitigate the effects of human disturbance and development. Short Term: Determine if land use patterns and physiological traits are correlated in stream fish species by (1) identifying stressors in disturbed (agricultural) streams (2) quantifying the impact these stressors have on the baseline physiological characteristics of stream fish (3) assess the impact of these stressors on the stress-induced physiological responses of stream fish (4) determining the cause for differential stress responses.

RATIONALE:

Land use planning attempts to limit the negative impacts of developing land and preserve natural ecosystems through evaluation and implementation of cost-effective management practices to mitigate the impacts of human activities on surrounding areas. To accomplish this, land use planners must first understand how changes in land use impact the organisms that live in the ecosystem that they are developing. In addition, many of the areas in which land use planners are trying to develop contain stream ecosystems where they must consider the health of fish communities to limit potential negative impacts. One branch of fisheries science that could provide land use planners with information to evaluate the health of fish communities are the physiological properties of fish which are considered biomarkers of fish health and essential in helping fish cope with stress induced by human land use practices. However, before physiological tools can be used to evaluate fish health and predict changes in fish community structure, we must first establish that land use patterns and physiological traits are correlated in stream fish species.

METHODOLOGY:

In order to meet the objectives of this study we conducted a complimentary set of experiments involving both field and lab based physiological sampling. A very brief description of the methods to accomplish each of the above stated objectives will be provided here: (1) Two replicate disturbed (agricultural) and two replicate undisturbed (forested) streams were chosen using GIS analysis (2) Stream characteristics such as thermal profiles and oxygen concentrations were monitored throughout the course of the study along with information on habitat characteristics such as stream depth, width, flow, and canopy cover. (3) Creek chub, a stream fish species of adequate size and abundance for physiological comparisons to be made between disturbed and undisturbed streams, were collected and sampled for blood and muscle from all streams in the field. (4) Creek chub were also collected, allowed to recover from transport stress,

and sampled for blood, muscle, and metabolic rate following high temperature and low oxygen challenges in the laboratory. (5) Creek chub were also collected from each stream and held in a reciprocal cross experiment which exposed fish from each site to the simulated thermal conditions of agricultural and forested streams.

KEY FINDINGS

The results of the field and lab based experiments are summarized here based on the outlined methodology described earlier. No tables and figures will be included here to protect the status and originality of data for future submission to scientific journals.

(1) Identifying stressors in disturbed (agricultural streams): Replicate disturbed (agricultural) streams had higher maximum temperatures and greater daily temperature change than undisturbed (forested) streams due to differences in the percentages of riparian land use and canopy cover in these streams. Stream morphological characteristics were similar between streams and did not drive differences in thermal profiles.

(2) Quantifying the impact these stressors have on the baseline physiological characteristics of stream fish: Creek chub from disturbed (agricultural) and undisturbed (forested) streams had nearly identical baseline physiological properties, indicating that creek chub living in disturbed environments are not negatively impacted and have acclimatized to the stressors they perceive in these environments.

(3) Assess the impact of these stressors on the stress-induced physiological responses of stream fish: Creek chub from disturbed (agricultural) environments had lower stress responses and were able to maintain physiological performance to high temperature and low oxygen challenges that are common to disturbed stream environments. This finding suggests that creek chub acclimatize and reduce their stress response to temperature and oxygen stressors in order to maintain physiological performance.

(4) Determining the cause for differential stress responses: Creek chub from agricultural and forested streams held at high temperatures for a prolong period lowered their stress response and were able to maintain physiological performance to high temperature challenges in the laboratory. This finding confirms that acclimation to thermal stress is important in causing observed reductions in stress responses that allow fish to maintain physiological performance to the thermal stress.

IMPACTS

(1) The results of this study serve as a basic foundation for future physiological research to help land use planners evaluate the impacts of various development practices. Specifically this study meets its short term objective and establishes that stream fish physiological responses and land use practices are correlated. This means that physiological evaluations have the potential to help land use planners not only detect disturbance but potentially mitigate poor development practices before disturbance in stream ecosystems can cause changes in fish community structure and population declines. Overall, this study serves as a first step by

establishing the link between land use and physiological responses so that future studies can explicitly test what changes in fish physiological responses occur following the use of various development and land use practices and what these changes mean for fish populations.

(2) This study demonstrates the ability of tolerant fish species to modify their physiological responses to maintain physiological performance and provides insight into the changes in community structure observed in aquatic ecosystems following human development. Specifically, creek chub are able to modify their stress responses based on perceived stressors in their local environment allowing them to maintain physiological performance to subsequent challenges. This ability likely allows them to cope with the challenges of "stressful" or disturbed stream ecosystems giving them with a distinct physiological advantage over sensitive fish species that may not have this ability. This means creek chub and other tolerant species may are able to make this modifications and thrive in disturbed streams while sensitive fish decline due to potential physiological constraints. Although much research is needed to provide direct evidence that these changes in stress responses are beneficial to creek chub, the results of this study suggest that physiological modifications may be an important cause for the changes in fish community structure and potentially fish population declines following human development of the terrestrial landscape surrounding streams.

ACCOMPLISHMENTS

(1) This study met all stated objectives of research project by demonstrating the importance of land use practices in terrestrial systems in shaping the physiological traits that determine the ability of fish to cope with stressors in stream environments (short-term goal). This information will serve as a foundation for future research developing physiological tools for use in detecting, understanding and mitigating the negative effects of anthropogenic alterations on stream ecosystems (long-term goal).

(2) Training principal investigator in planning, implementing, and completing a master's research project.
   a. Planning: experimental design, communicating research ideas to peers, writing grants
   b. Implementing: leading and training a research team on both field and laboratory physiological techniques, running experiments, data management
   c. Completing: analyzing data, summarizing results, presenting and communicating results both orally and in written form to the scientific community

(3) Presentations
   a. Oral presentation at the 2010 American Fisheries Society Meeting in Pittsburg, PA.
   b. Poster presentation at the 2009 Illinois American Fisheries Society Meeting in Rend Lake, Il.

(4) Impact of sea grant funding on research and above accomplishments
   a. Travel to stream locations to collect blood samples
   b. Purchase of kits to conduct physiological analysis

FUTURE PLANS AND IMPACT OF FUNDING ON THOSE PLANS

Without Indiana-Illinois funding this project would not have been able to be completed and would have failed to contribute to current and future scientific knowledge on the impact of stream degradation of fish species. Future research will be able to use this research to strengthen our understanding of the role that physiological evaluation has in answering ecological questions. In fact, these ideas are already being used to understand the effects of urban land use on the stress responses of stream fish in the physiological laboratory at the University of Illinois. In addition, this funding aided the principal investigator in developing skills associated with conducting a master's research project improving research, and communication abilities which are essential to be competitive for future jobs. The physiological techniques learned in this study will also likely be a part of the principal investigator and research assistant's future careers.