STUDY PERFORMANCE REPORT

State: Michigan

Project No.: F-80-R-8

Study No.: 230738

Title: Improve and validate river segment identification and classification models for assessing fishery potential and environmental impairment in Michigan.

Period Covered: October 1, 2006 to September 30, 2007

Study Objectives: The overall objective is to develop tools for assessing river fishery potential and environmental impairment for Michigan. The specific goals are to: (1) improve and validate models for predicting thermal and hydrological regimes, expected fish distribution, and expected physical habitat characteristics; (2) classify river segments; (3) conduct environmental impairment assessment; (4) provide site specific information required for establishing management goals; and (5) better understand how the management goals can be achieved.

Summary: During this reporting period, the co-principal investigators coordinated and participated in the processes of finalizing the models for predicting water temperature and flow discharges, as well as making water temperature and flow discharge predictions for all streams/rivers in Michigan. We also coordinated the activities for finalizing the models for predicting stream/river fish assemblages. The distributions of 93 streams/rivers fish species have been predicted for Michigan.

Findings: Jobs 2, 5, and 6 were scheduled for 2006-07 as amended in 2006-07 and 2007-08, and progress is reported below.

Job 2. Title: Develop models for predicting water temperature, flow discharge, and fish assemblages.–

Temperature Model: Final models for predicting Michigan's mean July stream temperature have been developed. These models were developed based on July mean stream temperature collected from over 700 stream sites and the landscape data associated with those sites at multiple spatial scales. A number of approaches were used to explore the best way of developing predictive temperature models. These methods included: (1) stepwise multiple linear regression models; (2) semi-parametric modeling of temperature through generalized additive models; (3) incorporating spatial trend surfaces in models; (4) temporal detrending of the temperature combined with regression prediction; (5) spatial regression, which included an autocorrelative error structure based on distances between sampling points; and (6) combining regression (both linear and nonlinear) predictions with kriging and co-kriging of residuals. The last approach developed by geo-statistical and generalized additive modeling has proven satisfactory. In this approach, kriging was used to interpolate broad spatial patterns in mean July stream temperature from 700 sites where temperature loggers were deployed. Spatial autocorrelation in the kriged estimates was determined through a spherical semivariogram, which was estimated via nonlinear least squares in S-PLUS (Insightful Corp., Seattle, Washington). Deviations of observed mean July stream temperatures from kriged temperature estimates were then computed for the temperature logger sites. Generalized additive modeling was used to develop a regression model for predicting deviations in observed temperatures from the kriged estimates based on landscape-level environmental variables. Variables used for predicting the deviations were determined using forward selection. Selected variables were natural log transformed network catchment area, mean

July air temperature in the network catchment, potential groundwater loading in the network catchment, mean soil permeability in the reach catchment, percent barren land type in the reach catchment, percent forested wetland in the reach catchment, percent ignaceous/metamorphic bedrock in the reach buffer, and percent agricultural land use in the reach buffer. Predicted mean July stream temperatures were calculated by summing the kriged temperature estimates with the predicted deviations from the fitted generalized additive model. This combined geo-statistical and generalized additive modeling approach to predicting stream temperature yielded temperature estimates that were within two degrees Celsius of observed mean July stream temperature for approximately 90% of a hold-out dataset. The correlation between predicted and observed stream temperatures for the hold-out dataset was approximately 80%.The temperature models were recently used to predict July mean water temperature for all river reaches in the State of Michigan, which completes the temperature modeling task of this study.

Flow model: Final statewide stream flow models were developed based on daily flow measurements from 68 U.S. Geological Survey (USGS) gauging stations that meet the criteria for flow model development. The criteria for selecting gauging stations were (1) having 20 years or more of continuous records that included the 1995 water year; (2) being not close to or downstream of a dam; (3) being not listed in the USGS water book as having flow regulated by dams (including power plants, lake outflow, and mill dams); (4) having no effluent additions, diversions, or mine pumpage; (5) having no diurnal fluctuations at low flow. These models were developed based on multiple regression between flow discharge data from USGS gauging stations and their corresponding catchment area, slope, annual precipitation, surficial geology, and land cover. Multiple linear regression was used to develop predictive models of annual and August exceedence flows (5, 10, 25, 50, 75, 90, and 95%). Model development began with a simple hydraulic geometry equation that included the catchment area, precipitation, and valley slope. Additional predictors were added to this base model in a stepwise fashion beginning with surficial geology summaries. When the base model with surficial geology had been developed, agricultural and urban land covers were added to all models because we were particularly interested in the influence of these predictors. These models were initially developed using the median flow and then checked against high and low flows for fit using the adjusted R^2 after each predictor was added. These models explained between 72% and 98% of the variation in flows. The flow models were recently used to predict exceedence flows for all river reaches in the State of Michigan, which completes the flow-modeling task of this study.

Fish modeling: The principal investigators have coordinated the planning and provided technical guidance to a Ph.D. graduate student to model fish occurrence. A fish assemblage database was assembled from various sources, including Michigan DNR and the University of Michigan. This database contains 920 stream sites with fish assemblage data collected using comparable sampling methods (backpack or tow-barge electrofishing) and sampling seasons (May to September). Different scale landscape data were linked to each of the fish sampling sites. The occurrence of 57 fish species have been predicted using CART statistical software.

Job 5. Title: Conduct environmental assessment and evaluate the achievability of fisheries management goals.–We identified reference reaches and human disturbance gradients for all wadeable Michigan streams that appear on the 1:100,000 National Hydrographic Dataset. The reference identification and disturbance gradient assessments were conducted using 27 human disturbance measures at different spatial scales. We first identified relations between fish indicator metrics and disturbance measures to identify at what level each of the disturbances had undetectable, detectable, moderate, and severe impacts on biological communities. We then used the identified disturbance levels to determine the health conditions of all wadeable stream reaches in Michigan. We last identified the top three disturbance sources for streams that had moderate to severe human disturbances.

We found that approximately 38% of coldwater and 16% of warmwater streams in Michigan were identified as being in the least-disturbed condition. Conversely, approximately 3% of coldwater and 4% of warmwater streams were moderately to severely disturbed by landscape human disturbances. Anthropogenic disturbances that appeared to have the greatest effects on moderately to severely disturbed streams were nutrient loading and percent urban land use within network watersheds. The strengths of our process for assessing stream health include the use of inter-confluence stream reaches as an assessment unit, the ability to evaluate stream health for all streams within large regions, and the development of an overall disturbance index that is a weighed sum of multiple disturbance factors. The robustness of our approach is linked to the scale of disturbances that affect a stream; it will be less robust for identifying less degraded or reference streams with localized human disturbances.

In conjunction with the stream classification (Job 4, completed in 2005-06), our reference identification, stream health status evaluation, and the key anthropogenic disturbances factor identification for individual stream reaches enable us to pinpoint management priorities and to evaluate the achievability of our fisheries management goals.

Job 6. Title: <u>Write progress report.</u>–This progress report has been prepared as scheduled.

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