STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-81-R-1

Study No.: 680 **Title:** Patterns in community structure, life histories, and ecological distributions of fishes in Michigan rivers

Period Covered: October 1, 1999 to September 30, 2000

Study Objectives: 1) To develop models that explain abundance patterns of the most common fishes in Lower Michigan streams; 2) to evaluate the role of landscape-scale characteristics of streams in favoring fishes having particular life history characteristics; 3) to develop an atlas describing the geographic and ecological distributions of fishes in Lower Michigan streams.

Summary: We amended the study to allow for further collection of summer stream temperature data. We finalized our approach to modeling fish densities and developed final models for common Michigan fishes. We used covariance structure analysis to test hypotheses regarding relations among correlated catchment-, reach-, and site-scale habitat variables and fish abundance. The results of these analyses will be presented in two Michigan Department of Natural Resources Fisheries Division research reports.

Job 3. Title: Develop ecological atlas.

Findings: Most data needed for constructing graphical models of fish ecological distributions were obtained under Study 631. Analysis of stream temperature model predictions indicated that models predictions were somewhat biased for Michigan Rivers Inventory (MRI) sites having July mean temperatures less than 18 ^{o}C or greater than 24 ^{o}C. Model predictions of the weekly range in July weekly temperature were inaccurate (R^2 = 0.13). As a result, this study was amended to allow for collection of additional measurements of stream temperature conditions at MRI sites having fish abundance data. This will enable development of more accurate graphical models relating these parameters to fish abundance. Through cooperative efforts with field personnel, we collected and summarized July 1999 temperature data for 31 MRI sites.

Job 4. Title: Write report.

Findings: We changed our approach to modeling fish densities after further analysis of preliminary logistic regression models developed in 1998-99. These 64 models were 84% correct (average of all models) in explaining species' presence or absence, but each model's ability to correctly predict presence or absence appeared to be influenced by how rarely or commonly a species occurred in the data (Figure 1). As a result, few of the models were reliable predictors of both presence and absence. Therefore, we used multiple linear regression techniques instead to develop two predictive models for each species. The two models were based on different sets of data: 1) sites having population estimates for the entire fish assemblage; and 2) only those sites where the species of interest occurred. The first set of models provides coarser-scale predictions for any site on Lower Michigan rivers and identifies important variables related to each species' distribution in Lower Michigan (Table 1). The second set of models gives higher-resolution predictions and identifies additional local-scale factors related to fish biomass. For example, the latter model for brown trout (Table 2) included only four independent variables (as opposed to nine in the former model), and suggested that among brown trout streams, higher brown trout biomass occurred in lower gradient rivers having colder July mean temperatures, more gravel, and less cobble. Models for all species will be presented in a Michigan Department of Natural Resources, Fisheries Research Report tentatively entitled, "Predictive models for common fishes in Lower Michigan rivers".

Teasing out the effects of individual habitat variables on fish biomass is complex due to collinearities among habitat variables. For example, do brown trout really have an aversion to cobble-bottomed streams, or is the negative coefficient for cobble the result of collinearities between it and the gravel or gradient variables? Covariance structure analysis (Maruyama 1998) allows the analyst to explicitly test theories regarding the effects of correlated variables on each other and on the dependent variable. We used such analyses to test hypothesized relations among catchment-, reach-, and site-scale habitat variables and fish abundance. This analysis will be presented in a MDNR Fisheries Research Report tentatively entitled, "Relations among catchment-, reach-, and site-scale habitat variables and fish abundance in Lower Michigan rivers".

Literature Cited:

Maruyama, G.M. 1998. Basics of structural equation modeling. SAGE Publications, Inc., Thousand Oaks, California.

Prepared by: Troy G. Zorn
Date: September 30, 2000

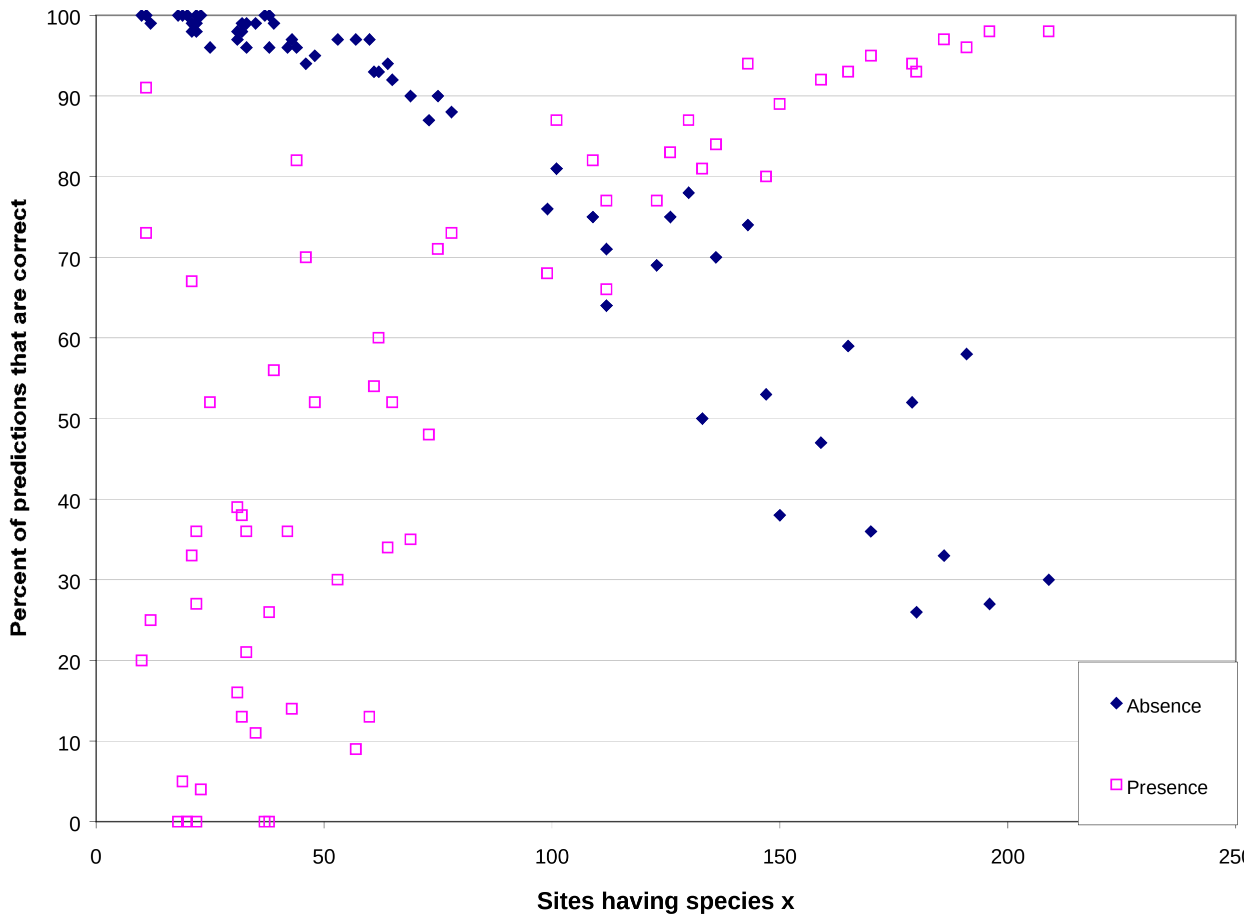

Figure 1.–Percent of sites having correct predictions of species' presence or absence plotted against the number of sites where each species occurs. Predictions are by preliminary logistic regression models developed for 64 species of fishes in Lower Michigan rivers. Plot shows that the ability of models to accurately predict both presence and absence is limited when fishes occur at few or many sites in the database.

Table 1.–Preliminary multiple linear regression model outputs for a) brown trout; b) common carp; and c) creek chub. Dependent variable was $\log_{10}$ (fish biomass + 0.001) expressed as kg/ha. Independent variables are as follows: BESTMEAN= measured (if available) or predicted July mean temperature in C; BESTMEA2= BESTMEAN squared; LG90CMSK= $\log_{10}$ of the measured (if available) or predicted 90% exceedence flow divided by drainage area in cms/km^2; LG90CMK2= LG90CMSK squared; GRAVELLG= percent of the substrate that is gravel or larger; BNKST= percent of streambank at the site that is stable; GRADPERC= reach gradient as a percent; LGBWATER= $\log_{10}$ percent lakes, ponds, and streams in a 2-km total width buffer of the upstream drainage network; PONDUPST= the occurrence of a pond less than 3-km upstream of the site (1=yes; 0=no); BIGRIVER= if the site is on or is connected to a big (>1000 km$^{2)}$ river (1=yes; 0=no); OUTWGEO= percent of the catchment comprised of outwash geology; TOTPPM measured (if available) or predicted summer total phosphorus in mg/L; LOGDAKM= $\log_{10}$ of the measured drainage area in km^2, LGAGRIC= percent of the catchment having agricultural land use.

a) Brown trout

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.627	.394	.370	1.2757

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	244.170	9	27.130	16.669	.000
Residual	375.959	231	1.628		
Total	620.129	240			

Coefficients

Variable	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	-9.584	3.397		-2.821	.005
BESTMEAN	.888	.305	1.621	2.910	.004
BESTMEA2	-2.614E-02	.007	-1.904	-3.619	.000
LG90CMSK	1.875	.565	.679	3.320	.001
LG90CMK2	.364	.171	.417	2.127	.035
GRAVELLG	1.280	.315	.231	4.061	.000
GRADPERC	-.587	.268	-.181	-2.192	.029
LGBWATER	-.624	.206	-.214	-3.029	.003
PONDUPST	-.643	.227	-.154	-2.839	.005
OUTWGEO	1.730	.445	.263	3.891	.000

b) Common carp

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.697	.486	.474	1.7515

Table 1.–Continued

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	743.914	6	123.986	40.414	.000
Residual	785.375	256	3.068		
Total	1529.289	262			

Coefficients

Variable	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	8.048	3.132		2.570	.011
TOTPPPM	10.881	3.536	.180	3.078	.002
LG90CMSK	-.394	.208	-.096	-1.890	.060
LOGDAKM	1.431	.237	.470	6.045	.000
LGAGRIC	.803	.323	.155	2.486	.014
BESTMEAN	-1.414	.309	-1.732	-4.578	.000
BESTMEA2	3.673E-02	.008	1.793	4.856	.000

c) Creek chub

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.591	.350	.335	1.4133

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	243.866	5	48.773	24.417	.000
Residual	453.437	227	1.998		
Total	697.303	232			

Coefficients

Variable	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	-16.256	2.506		-6.487	.000
BESTMEAN	1.776	.254	3.049	6.981	.000
BESTMEA2	-4.328E-02	.006	-2.943	-6.775	.000
BNKST	-7.515E-03	.003	-.160	-2.893	.004
LOGDAKM	-.791	.190	-.356	-4.166	.000
BIGRIVER	.755	.242	.183	3.117	.002

Table 2.–Preliminary multiple linear regression model output for brown trout based on sites where brown trout occurred. Dependent variable was $\log_{10}$ (fish biomass + 0.001) expressed as kg/ha. Independent variables are as follows: BESTMEAN= measured (if available) or predicted July mean temperature in C; GRADPERC= reach gradient as a percent; SUBGR= percent of the substrate that was gravel; SUBCO= percent of the substrate that was cobble.

Brown trout- sites with >0 kg/ha

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.683	.467	.445	.5610

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	27.018	4	6.755	21.460	.000
Residual	30.846	98	.315		
Total	57.865	102			

Coefficients

	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	5.081	.537		9.459	.000
GRADPERC	-.218	.103	-.174	-2.127	.036
SUBGR	6.090E-03	.002	.516	2.622	.010
SUBCO	-1.006E-02	.003	-.706	-3.547	.001
BESTMEAN	-.208	.028	-.610	-7.452	.000