STUDY PERFORMANCE REPORT

State: Michigan

Project No.: F-81-R-2

Study No.: 680

Title: Patterns in community structure, life histories, and ecological distributions of fishes in Michigan rivers

Period Covered: October 1, 2000 to September 30, 2001

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: I identified 113 Michigan Rivers Inventory (MRI) sites in Michigan's Lower Peninsula that had population estimates for either salmonids or the entire fish assemblage. Electronic temperature recorders were placed into rivers at 57 MRI sites to obtain hourly readings in July 2001. Modeling efforts to explain distribution and abundance patterns of 68 common fishes in Lower Michigan rivers have continued. Statistically significant, multiple linear regression models were developed to predict standing crop of each species. Good fits occurred for many game fishes. Catchment area, July mean temperature, channel gradient, total phosphorus, and amount of gravel or coarser substrates occurred most frequently in species models. I am presently developing regression models for each species based solely on sites where it occurs to better understand finer-scale influences on fish standing crops.

Job 3. Title: Obtain temperature and fish data as necessary.

Findings: I identified 113 Michigan Rivers Inventory (MRI) sites in Michigan's Lower Peninsula that had population estimates for either salmonids or the entire fish assemblage. Electronic temperature recorders were placed into rivers at 57 MRI sites to obtain hourly readings in July 2001 (Figure 1). Recorders will be recovered in fall 2001 and the data downloaded and summarized for use in developing an atlas relating July temperature characteristics to standing crops of fishes.

Job 5. Title: Write report.

Findings: Modeling efforts to explain distribution and abundance patterns of 68 common fishes in Lower Michigan rivers have continued. I used multiple linear regression modeling to develop a set of best regression models for predicting the standing crop of each species. Each model was based on habitat and fish standing crop data for 263 MRI sites. Models statistically significant at a P-value of 0.01 were developed for all species. Model fit (R^2) values ranged from 0.04 to 0.51 with good fits occurring for many fishes, including important game species such as smallmouth bass, chinook salmon, brook trout, brown trout, and rainbow trout (Table 1, Figure 2).

The frequency of occurrence of significant model variables across the set of models provides some indication of the relative importance of habitat variables measured at different spatial scales to fish assemblages in Lower Michigan rivers. Catchment area, July mean temperature, channel gradient, total phosphorus, and amount of gravel or coarser substrates occurred most frequently in species models (Table 2). Common occurrence of these habitat variables suggests they (or their correlates) are highly important in shaping fish assemblages across Lower Michigan. Similar combinations of these habitat variables were identified as important by others (e.g. Lyons 1996 and Degerman and Sers 1993) studying fish assemblage patterns across other large regions. Many other variables were identified as significant for individual species, though they were less common across the entire set of models (Table 2).

Identifying the patterns observed in ecological data and underlying processes responsible for them, and understanding how those relationships change with each analysis are central problems in ecology (Levin 1992). My aforementioned analysis focused on broad spatial patterns in fish distributions with large contrasts in physical conditions between MRI sites. I am presently conducting a similar regression analysis using the same dataset, with one difference. For each species model, I will be looking solely at sites where the species occurs. This analysis will likely result in models for each species that are based on MRI sites having smaller contrasts in physical conditions. These models should also have utility to fishery managers, because they will likely identify additional local-scale factors correlated with fish standing crops that were not significant in the previous analysis due to its inclusion of all 263 MRI sites.

Literature Cited:

Degerman, E. and B. Sers. 1993. A study of interactions between fish species in streams using survey data and the PCA-hyperspace technique. Nordic Journal of Freshwater Research 68:5-13.

Levin, S.A. 1992. The problem of pattern and scale in ecology. Ecology 73(6):1943-1967.

Lyons, J. 1996. Patterns in the species composition of fish assemblages among Wisconsin Streams. Environmental Biology of Fishes 45:329-341.

Prepared by: Troy G. Zorn
Date: September 30, 2001

Table 1.–Results of multiple linear regression models for 68 common fishes in rivers of Michigan's Lower Peninsula. Results are sorted by decreasing adjusted R^2 values. Species densities were transformed as $\log_{10}(x + 0.001)$ where x equals fish density in kg/ha. Models with an asterisk were developed only from sites accessible to the Great Lakes. Significance of regression constant coefficients is indicated by fonts as follows: <0.01 (regular); 0.01<p<0.05 (bold); 0.05<p<0.10 (italic), 0.1< (bold and italic).

Species	Constant	Adjusted R^2	SE of Estimate	ANOVA P-value	n
Smallmouth bass	-5.22	0.51	1.31	<0.001	228
Grass pickerel	*-1.39*	0.49	0.95	<0.001	234
Chinook salmon*	***-3.58***	0.49	0.78	<0.001	45
Common carp	**7.44**	0.47	1.75	0	262
Brook trout	1.24	0.47	0.98	<0.001	262
Quillback	-3.96	0.45	0.73	<0.001	244
Rock bass	-4.61	0.43	1.31	0	241
Bluntnose minnow	-4.44	0.42	1.13	<0.001	212
Slimy sculpin	-4.99	0.41	0.61	<0.001	240
Central mudminnow	-11.20	0.40	1.11	<0.001	238
Northern hog sucker	-5.34	0.39	1.57	0	238
Channel catfish	***0.75***	0.39	1.14	0	250
Mottled sculpin	**-5.31**	0.38	1.14	0	230
Spotfin shiner	***1.92***	0.36	0.93	0	217
Brown trout	-9.66	0.36	1.29	<0.001	240
Golden redhorse	-5.39	0.35	1.71	0	231
Blackside darter	-5.14	0.35	1.04	<0.001	215
Northern pike	-3.52	0.35	1.42	0	247
Stonecat	-5.04	0.34	1.43	0	242
White sucker	***-0.97***	0.34	1.39	<0.001	258
Creek chub	-16.26	0.34	1.41	0	232
Flathead catfish	-1.85	0.33	0.70	0	252
Rainbow trout	-3.32	0.33	0.90	<0.001	231
Gizzard shad	-3.88	0.32	0.72	0	252
Yellow bullhead	8.15	0.32	1.42	0	245
Blacknose dace	-13.23	0.30	1.30	0	259
Johnny darter	-2.35	0.30	0.99	<0.001	222
Freshwater drum	-3.63	0.29	0.56	0	252
Walleye	-3.66	0.28	1.00	0	248
Black crappie	-1.77	0.28	1.05	0	255
Green sunfish	1.12	0.27	1.29	0	230
Pumpkinseed	-1.90	0.25	1.25	<0.001	238
Tadpole madtom	-3.85	0.25	0.80	<0.001	257
Largemouth bass	***-0.52***	0.25	1.24	<0.001	231

Table 1.–continued.

Species	Constant	Adjusted R^2	SE of Estimate	ANOVA P-value	n
Longnose dace	-10.43	0.24	0.69	<0.001	234
River chub	-5.26	0.23	0.88	<0.001	238
Redfin shiner	-3.06	0.21	0.50	<0.001	242
Brook silverside	-5.73	0.21	0.66	0	245
Logperch	**-1.20**	0.21	1.02	<0.001	246
Greater redhorse	-2.65	0.21	1.13	<0.001	241
Central stoneroller	***0.63***	0.20	1.07	<0.001	228
Rainbow darter	-13.85	0.18	1.07	<0.001	242
Bluegill	3.28	0.17	1.34	<0.001	229
Spotted sucker	-1.88	0.17	0.77	<0.001	244
Burbot	-11.02	0.17	0.85	<0.001	262
White crappie	-2.55	0.17	0.57	<0.001	240
Rosyface shiner	-7.46	0.17	0.99	<0.001	243
Shorthead redhorse	-2.73	0.16	1.39	<0.001	235
Coho salmon*	-3.71	0.16	0.37	<0.01	38
Common shiner	-4.45	0.16	1.55	<0.001	243
Greenside darter	-3.92	0.16	0.75	<0.001	241
Striped shiner	-3.58	0.16	0.87	<0.001	234
Hornyhead chub	-14.22	0.15	1.49	<0.001	224
Black redhorse	-2.36	0.15	1.24	<0.001	231
Pirate perch	-2.54	0.14	0.76	<0.001	236
Lake chubsucker	-3.63	0.14	0.47	<0.001	257
Sand shiner	-3.90	0.14	0.73	<0.001	224
Fathead minnow	-1.65	0.14	0.53	<0.001	240
Black bullhead	-5.43	0.13	1.18	<0.001	237
Yellow perch	-1.98	0.13	1.00	<0.001	255
Brown bullhead	-3.49	0.13	0.84	<0.001	230
Mimic shiner	-4.93	0.12	0.62	<0.001	230
Longear sunfish	***-1.02***	0.11	0.82	<0.001	250
Brook stickleback	-2.84	0.10	0.54	<0.001	244
Silver redhorse	-3.66	0.09	1.00	<0.001	251
Bowfin	-2.09	0.08	0.81	<0.001	262
Northern redbelly dace	-1.89	0.05	0.56	<0.01	252
Golden shiner	-3.47	0.04	0.67	<0.01	243

Table 2.–Frequency of occurrence (and sign of coefficients) of variables in multiple linear regression models that predict standing crops of 68 common fishes in rivers of Michigan's Lower Peninsula. General variable descriptions are used because different forms of many variables were combined. Variables are sorted by decreasing total number of occurrences. Models for some fishes with intermediate habitat preferences (e.g., moderate July temperatures) contained both positive and negative coefficients for similar variable forms, so total occurrence values may be less than the sum of positive and negative coefficients. Variable types are: E- energetic; SH- Site-scale hydraulic and hydrology; SG- Site-scale physical geomorphic; R- Reach-scale channel character and connectivity; C- catchment-scale.

Variable Type	Total occurrences	Number of Negative coefficients	Number of Positive coefficients	Variable description
C	38	22	31	Catchment area
E	28	22	21	July mean temperature
R	24	20	4	Channel gradient
E	18	6	12	Total phosphorus
SG	17	3	14	Gravel or coarser substrates
SG	15	10	5	Bank stability
R	14	3	11	Proportion water in the upstream river network
C	14	3	11	Proportion agricultural land use in catchment
R	13	4	9	Site is accessible to Great Lakes
SH	12	5	7	90% exceedence flow yield
R	11	3	8	Proportion water and wetlands within 4 km upstream
R	11	6	5	Proportion non-forested wetlands in 2 km total width upstream riparian buffer
R	11	4	7	A lake or pond is <3.5 km upstream of site
C	11	6	5	Proportion coarse geology in catchment
SG	10	4	6	Percent riffle
C	10	5	5	Proportion water and wetlands in catchment
SH	9	3	6	Depth at 90% exceedence flow
R	9	4	5	Site is on or connected to a river having a CA > 1000 km^2
R	9	5	4	A barrier occurs between site and the next considerably larger reach downstream
SG	8	2	9	Sand or finer substrates
R	8	3	5	Sinuosity
R	8	2	6	Proportion agricultural land use in 2 km total width upstream riparian buffer
C	8	6	2	Proportion urban land use in catchment
C	7	5	2	Proportion fine geology in catchment
SH	6	3	3	10% exceedence flow yield
R	6	6	0	Proportion urban land use in 2 km total width upstream riparian buffer
C	6	3	3	Proportion outwash geology in catchment
SH	4	1	3	Velocity at 90% exceedence flow
DR	2	0	2	Recent distribution range
SG	2	1	1	Percent of riparian corridor as brush, deciduous, or coniferous
C	2	0	2	Proportion forest in catchment
C	2	1	1	Proportion coarse and outwash geology in catchment

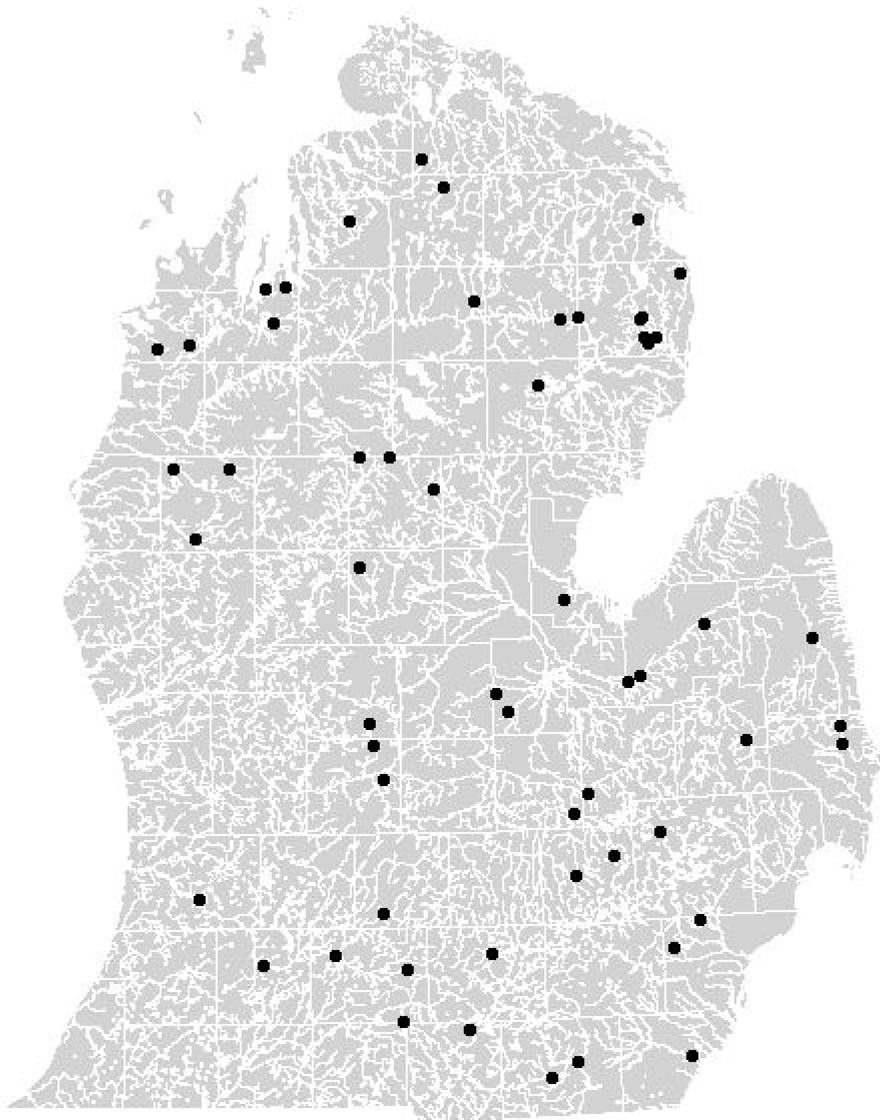

Figure 1.–Locations of Michigan Rivers Inventory sites where electronic thermometers were deployed to obtain hourly water temperature readings during July 2001.

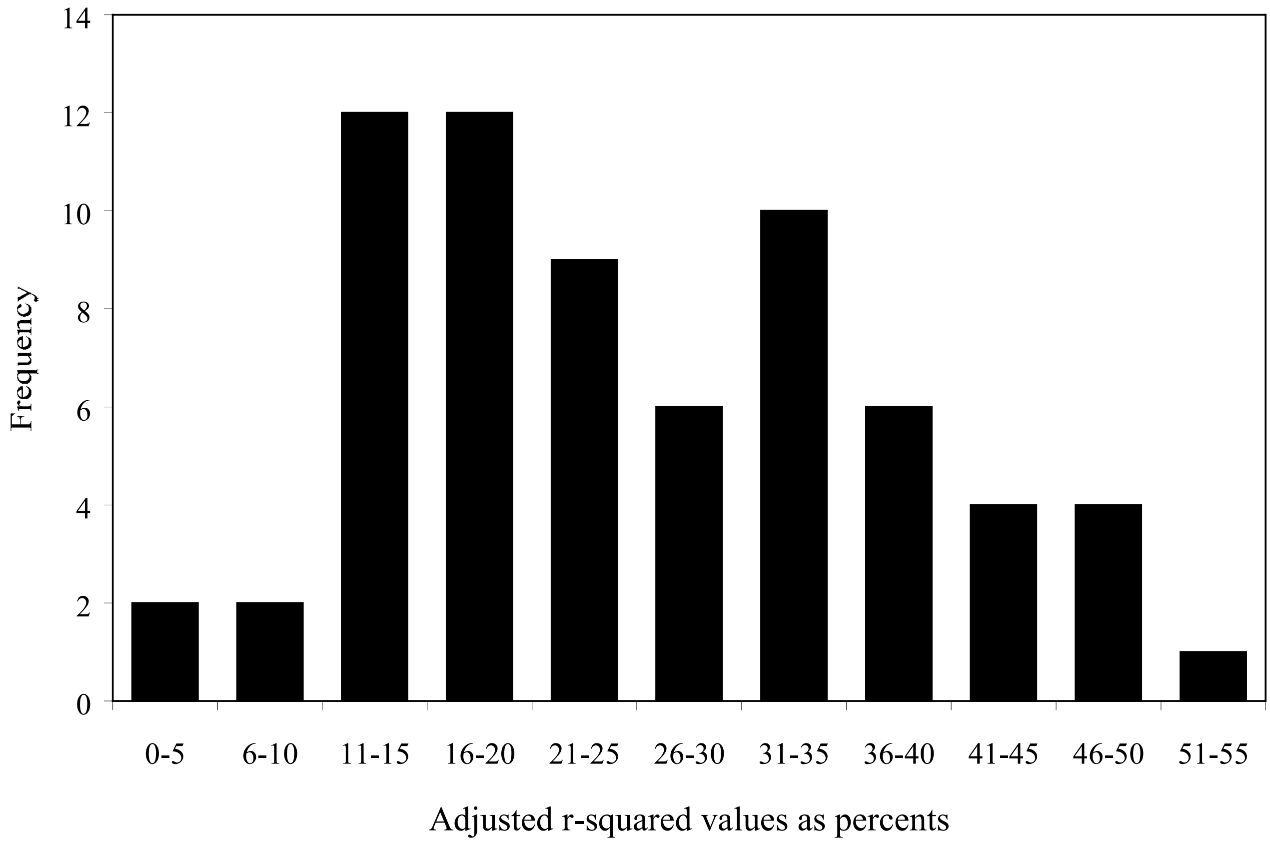

Figure 2.–Histogram of adjusted R^2 values in multiple linear regression models that predict standing crops of 68 common fishes in rivers of Michigan's Lower Peninsula.