STUDY PERFORMANCE REPORT

State: Michigan **Project No.:** F-80-R-5

Study No.: 230722 **Title:** Implications of lakeshore development for fishery resources in Michigan

Period Covered: October 1, 2003 to September 30, 2004

Study Objectives: Develop models integrating information from the literature and from new data collections to predict the response of fish populations and communities to lakeshore development.

Summary: In this project, I have continued to review the literature and develop a modeling framework for linking the effects of shoreline development on fish population dynamics. An outline of the conceptual framework is presented, as is a draft of a field research agenda for the Fisheries Division to consider as they continue to pursue this issue.

Findings: Jobs 1, 2, 3, 4, and 5 were scheduled for 2003-04, and progress is reported below.

Job 1. Title: Review literature.–I have continued to review pertinent literature, focusing in part on literature specific to largemouth bass *Micropterus salmoides*. I also attended a meeting at the annual American Fisheries Society focused on fish habitat. During this meeting, participants worked specifically on developing indicators of habitat health. These discussions were helpful in hearing other's perceptions of what is available in the literature.

Job 2. Title: Develop initial modeling framework.–A conceptual model for largemouth bass in lakes was developed (Figure 1). This model is consistent with conceptual modeling presented in last year's report, and will form the basis for future model refinement.

Job 3. Title: Develop a field research agenda.–During the past year, I have reviewed material prepared by the Fisheries Division's Lake Habitat Committee, and have met with other researchers on their work linking fish population dynamics to lake habitat conditions. Attachment A outlines a preliminary field research agenda and program for addressing the problems ensuing from lakeshore development.

Job 4. Title: Collaborate in the analysis of data from the resource inventory program.–Data from the resource inventory program are still in a preliminary state. I have met with Kevin Wehrly to discuss data analysis strategies.

Job 5. Title: Prepare annual report and communicate program results.–No work was done on this job during the current year except for preparing this report.

Prepared by: Daniel Hayes
Dated: September 30, 2004

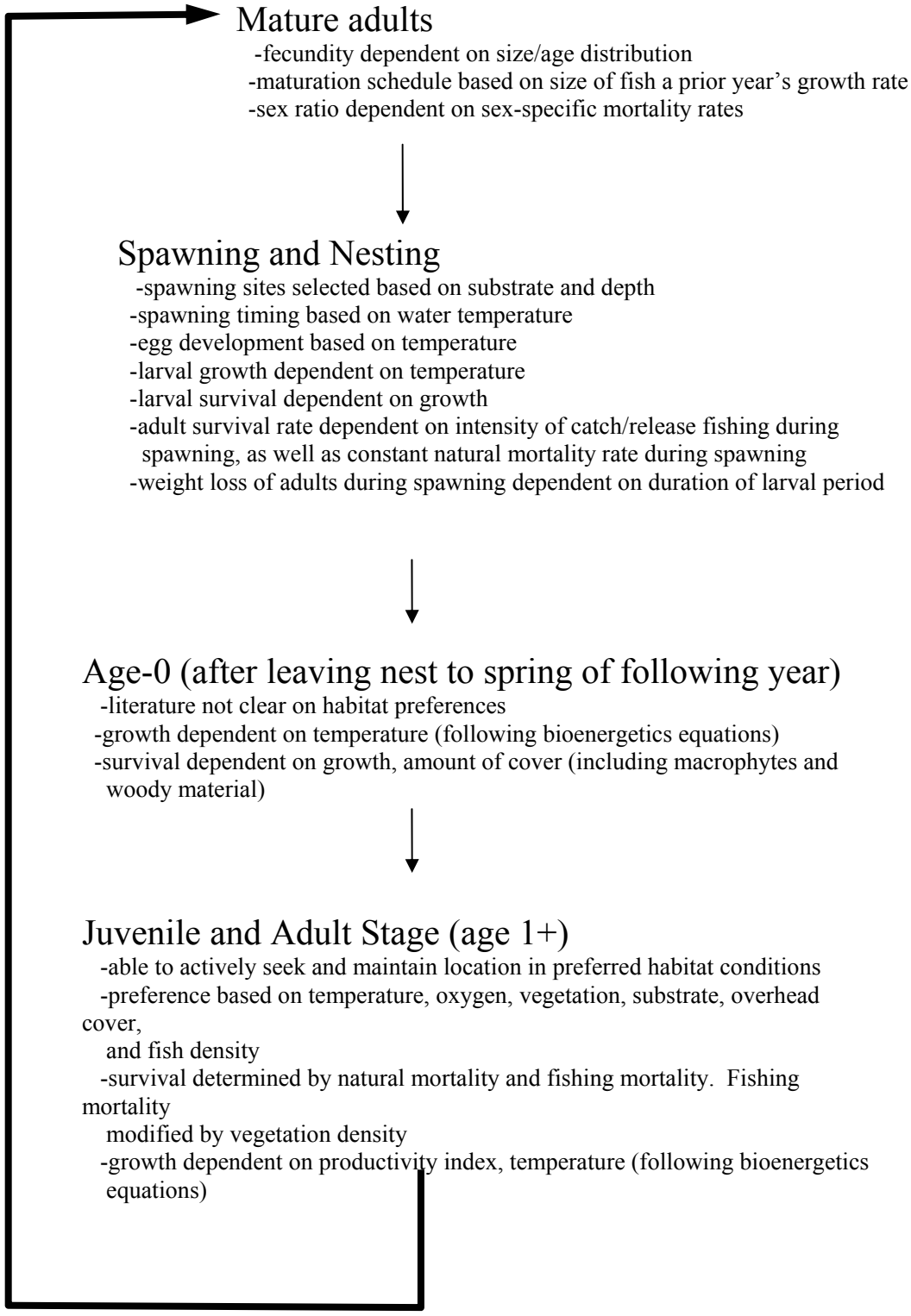

Figure 1.–Conceptual model of the relationship between largemouth bass population dynamics and lake habitat condition.

Attachment A. DRAFT

Draft Field Research Agenda for Determining Fishery Impacts of Lakeshore Development

Problem Statement

An important first step in the process of developing a research agenda is to clearly define what is meant by "lakeshore development." In the context of this paper, I will define lakeshore development to include 1) direct alterations of the lake shorelines and 2) direct alterations of riparian areas immediately adjacent to lake shorelines. This would include human alterations such as installing docks, beach creation/grooming, seawalls or other shoreline armoring, removal or replacement of natural shoreline vegetation. The changes in upland land cover (e.g., removal of forest cover in areas not adjacent to the shoreline) certainly can have an impact on lake ecosystems, but the focus of this work is on the impact of human activity along the shoreline.

Another critical consideration is the scale at which impacts are measured and evaluated. The proximate effect of lakeshore development is often to alter the distribution of fishes, but the primary fishery interest is in how this re-distribution results in whole-lake fish population response. Related to the issue of scale is how cumulative effects of shoreline development potentially lead up to abrupt shifts in fish populations. Also, the spatial location of shoreline development is of potential importance; do alterations that occur on "critical habitats" have a greater impact than the same activity in less critical habitat?

In addition to alterations to lakeshore habitat, development often leads to multiple confounding effects. For example, when docks are built they not only alter habitat, but potentially allow for more boat traffic and more anglers. There is also often more demand for stocked fish where lakeshores are more developed. Introduction of exotic species (e.g., milfoil, zebra mussels) is also a common byproduct of lakeshore development and human use. The full effects of these confounding effects are also poorly known, making it difficult or impossible to remove their impact with statistics or mathematical models.

Current State of Knowledge:

The current state of knowledge in the peer-reviewed literature regarding the lake-wide impacts of shoreline development is relatively limited. Some points that appear to be reasonably well documented include:

1. Fish community composition at the site level can be related to shoreline habitat conditions (Jennings et al. 1999)

2. Shoreline development often results in removal of coarse woody material. This can reduce or alter abundance and growth of fishes (Christensen et al. 1996; Schindler et al. 2000, Jennings et al. 2003)

3. Lakeshore development generally results in increased nutrient input (Carpenter et al. 1998)

4. Lake-wide increases in aquatic macrophyte coverage often occur (presumably due to nutrient input), but localized reduction in macrophyte coverage (Unmuth et al. 1999; Radomski and Goeman 2001) can also occur due to removal. The loss of emergent and floating-leaf vegetation at the site and lake level are associated with increasing development (Jennings et al. 2003)

5. Changes to shoreline substrate characteristics (NRC 1992; Jennings et al. 1999) often occur with shoreline development. Jennings et al. (2003) documented an increase in substrate embeddedness in the vicinity of lakeshore houses. Also, embeddedness was higher in lakes with higher density of development in addition to the local effect of individual houses.

Approaches:

Several approaches can be taken to determine the impact of lakeshore development on lake fisheries. Each of these broad approaches is outlined below, along with some of their strengths and weaknesses. It should be emphasized that these approaches are not mutually exclusive, and that the combined use of several approachs at the same time, or even on the same set of lakes, may increase the scientific gains that can be realized.

1. **Correlational** - look at whole lake fish community characteristics (e.g., species composition, abundance, growth) and correlate to level of development

   A correlational approach examining the relation between whole-lake fish relative abundance and lakeshore development is useful for determining if there is a strong "signal" observable despite the inherent variability among lakes. Although this approach does not provide a cause-and-effect picture of the relationship, and hence is open to criticism because of the potential impact of factors that are confounded with lakeshore development (e.g., increased fishing pressure), it can provide useful guidance on the likely consequences and the potential magnitude of the responses to lakeshore development. This approach has the additional problem that the effects of confounding factors (e.g., increased angling pressure) can not be readily removed.

2a. **Within-lake detailed field study** - examine fish distribution within lake and relate to shoreline conditions and individual

   One of the main problems with this approach is that the scale of observation does not necessarily scale up to whole-lake response. Even if fish distribution is altered, there is no clear link to changes in fish abundance. An advantage of this approach is that it is easy to communicate findings. Further, sample sizes can be relatively large because the unit of observation is individual site.

2b. **Within-lake detailed field study** - evaluate how critical population processes (e.g., reproductive success) vary within lakes with heterogeneous habitat conditions

   This approach also suffers from the problem that results on individual population processes do not necessarily scale up to whole-lake response. This approach would complement modeling analyses, however, and would provide insight into why the responses observed in approach 2a occur.

3. **Modeling** - use models to make predictions of response

   Modeling is an important tool for synthesizing results of studies, and for making predictions outside of the range of observations. This approach poses numerous problems, however. First, the models are likely to have substantial uncertainty, and as such are wide open to challenge. Secondly, the data to develop "good" models currently do not exist, and will require strong directed support from field research.

4a. **Experimental manipulation at the whole lake scale** - In theory, could manipulate a lake or set of lakes and evaluate response.

This approach is probably not at all feasible, but would provide the most defensible position and provide the most mechanistic understanding of the processes involved.

4b. Experimental manipulation at the within lake scale - Through use of telemetry, could evaluate actual use of habitats by fishes, and use data to determine how critical population rates vary as a function of habitat conditions as modified by lakeshore development. Could also experimentally manipulate fish density to determine "carrying capacity."

This approach poses problems similar to within lake observational studies in that the scale is not at the whole population level. By determining key population rates (e.g., survival rates) in different habitats, this approach would strongly complement a modeling approach. Manipulations of fish density (instead of habitat manipulations) provide a feasible method of determining how habitat features limit fish populations.

A draft agenda:

Given the above suite of approaches open to investigating the impact of lakeshore development on fish populations, an outline of a research agenda to address this problem is provided below. The agenda would necessarily include a mix of approaches, and would have some elements that can be accomplished relatively quickly and other elements that will require a sustained effort over a longer period of time. Further, the strategy should identify two qualitatively different outcomes of research. The first outcome is basic scientific knowledge about the relationship between fish habitat and fish population dynamics, and how lake habitats respond to lakeshore development. This outcome is broadly useful in the context of evaluating lakeshore development, and provides further benefits to other situations where fish habitat is threatened or where habitat enhancement is being contemplated. The second outcome consists of specific results oriented to providing immediate guidance on specific lakeshore development proposals or issues.

There are numerous areas where the Fisheries Division of the Michigan Department of Natural Resources can have an impact on lakeshore development; the predominant direct effect fishery managers can have is in the area of permit review. Some particular areas that relate to permit review that are likely to have the greatest impact on fishery resources include 1) Effects of shoreline hardening (seawalls); 2) Effects of macrophyte control (harvesting, chemical treatment); 3) Effects of beach creation or maintenance; and 4) Dredge and fill permits. Although other human activities have an impact on lake habitats, the above list outlines some of those activities that potentially have a substantial impact on fish habitat, and further, are areas where the permit review process provides a clear opportunity to sway proposed activities.

Research to provide specific guidance on lakeshore development

The whole-lake correlation approach (approach 1) provides an initial basis for determining the response of fish populations to lakeshore development. Data to support this approach are largely being collected through the resource inventory process, and substantial research benefits can be obtained relatively inexpensively by providing additional funds to collect relevant data on lakeshore development (where it is not collected as part of the routine resource inventory) as well as funds to summarize and analyze these data.

This approach should be augmented by analysis of detailed within-lake distribution patterns of fishes (approach 2a). These data may be collected as part of the resource inventory process, but it is unclear if the level of resolution (e.g., are catches being recorded by individual nets) is sufficient to answer the key questions. As above, substantial research benefits can be accrued by additional funds for work that coordinates with ongoing resource inventory efforts.

Research to provide general knowledge on fish habitat - fish population relationships, relevant to lakeshore development

Implementing approach 2b (within-lake process-oriented research) can be used to provide focused answers regarding how fish respond to lakeshore development, as well as provide broader insight into how fish populations respond to habitat conditions. This approach would require substantial funding to implement at a reasonable number of sites, and would also require the use of modeling (approach 3) to truly synthesize the results and place them in the context of predicted whole-lake response.

Approach 4b (whole-system manipulation) would be complementary to within-lake process oriented research (approach 2b) and modeling (approach 3), but likewise would require substantial funding to implement. In the long run, this approach shows promise for addressing multiple questions regarding the relationship between fish population dynamics and habitat quality, and would provide defensible solutions to many issues faced in lake fishery management.

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