GREAT LAKES FISHERY COMMISSION

2003 Project Completion Report[1]

Assessing Gains and Losses of Riverine Habitat in the Great Lakes

by:

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ASSESSING GAINS AND LOSSES OF RIVERINE HABITAT IN THE GREAT LAKES

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Introduction

In its Vision Statement for Healthy Ecosystems (GLFC 2001), the Great Lakes Fishery Commission identifies the conservation and rehabilitation of native fish populations, species, communities, and their habitats as a high priority. The Commission's milestone for habitat improvement (milestone 4) stresses the comprehensive assessment of gains and losses in aquatic habitat for each Great Lake, and the organization and initiation of an interagency effort to protect and restore critical habitats. The corresponding milestone for gaining new information (milestone 5) stresses the assessment of causes of change in Great Lakes fish communities and the provision of a workable method of detecting gains and losses in critical Great Lakes habitat by 2005.

The conservation and rehabilitation of aquatic habitats important to fishes are pressing needs. The Great Lakes basin is home to 40 million people and 50% of North America's industry (Groop 1999). Its resources are relied upon for drinking water, food, recreation and industry. Much of the original, physical habitat important to fishes in the lakes proper and their drainage basins has been lost since the 1800's, before it could be inventoried and before its value was understood, thus making existing remnants both scarce and that much more valuable (GLFC 2001). Today, aquatic habitat continues to be lost despite government efforts to regulate development within the basin. These losses are likely to continue. Human population growth within the basin remains a concern as a new baby boom is expected by the end of the 21st century's new decade (GLIN 2003). The effects of urban sprawl (GLIN 2003b) and climate change (Vorosmarty et al. 2000, Schindler 2001, Chu et al. 2003) are also pressing concerns.

The Commission's habitat milestones present enormous practical and conceptual challenges. From a practical perspective, the Great Lakes basin is the largest freshwater ecosystem in the world and inhabited by a rich diversity of aquatic organisms, including over 160 native fish species. This large geographic extent, combined with limits on monetary resources, creates the basis for a tradeoff between the comprehensiveness and intensiveness to which individual regions and species can be examined. Shared management by agencies from two countries, one province, and eight states presents a further challenge. From a conceptual perspective, the theory surrounding habitat science is poorly developed. Habitat is an integrative concept (Ford 2000), a theoretical construction about the properties of ecological systems that cannot be measured directly. What is meant by critical habitat is even more challenging to define and measure. Moreover, the spatial scales at which individual aquatic organisms interact with their surroundings on a day-to-day basis is typically different than the spatial scales at which habitat changes are occurring and being observed (Matthews 1998). The links between the general habitat features important to fishes and the features that would be inventoried has not been examined satisfactorily.

This paper focuses on the Commission's habitat milestones in relation to riverine aquatic habitats. It's primary objective is to consider whether the Commission's Habitat Milestone as described in the Vision Statement is achievable as is, achievable with modification, or unachievable and in need of reconsideration. The paper first proposes explicit management objectives describing how a method of detecting gains and losses would be used. It then develops a schematic linking the drivers of habitat change with habitat features that could be measured and habitat features that fish interact with to reveal key research challenges and opportunities. Following this, it develops and describes the critical components needed to measure changes in aquatic habitat and reviews conceptual approaches and technical methods available to describe the amount and state of existing habitat resources. Lastly, it provides recommendations where the GLFC can make significant management and research contributions. The contents of the paper were developed, in part, from a facilitated, GLFC-sponsored workshop held 20-21 August 2003 in Romulus, MI. The workshop involved participants with diverse interests, backgrounds, and skills related to quantifying aquatic habitats. The participants were scientists and technical experts from academic and management institutions inside and outside of the Great Lakes basin. Summaries of the workshop organization, discussions, as well as contact information for participants are provided in Appendices 1-3, respectively.

Proposed Management Objectives

The GLFC's Vision Statement lays out specific milestones and, in some cases, such as the milestone of developing a workable method of detecting habitat gains and losses, specific time lines for achievement. However, the Vision Statement does not explicitly specify what management objectives will be addressed with the habitat inventories and method of detecting gains and losses - that is, exactly how would the results of these analyses be used and at what temporal and spatial scales? Specification of these objectives is critical to correctly selecting the attributes to be measured, the scales at which to measure them, and the analyses to be employed. Workshop attendees strongly felt that the lack of clear management objectives was a major impediment to developing a work plan that addresses the milestones.

We propose that the Commission's objective be to develop a method of quantifying, forecasting, and backcasting basin-wide changes in riverine habitat at spatial and temporal scales appropriate to support land-use decisions aimed at conserving critical habitat and rehabilitating or restoring degraded habitat within the Great Lakes basin. This objective is consistent with the milestones in the Vision Statement, which emphasize conservation of critical habitat, rehabilitation/restoration of degraded habitat, and identification of rates of gains and losses of different habitats. The remainder of this paper is written on the assumption that this objective captures the spirit of what the habitat milestones were intended to achieve and how the habitat information would be used.

Toward Defining Aquatic Habitat: A Conceptual Framework

In this section, we refine the definition of aquatic habitat by developing a conceptual framework describing how determinants of environmental change are hypothesized to influence biodiversity through habitat. Our framework will focus on fishes in riverine habitats, but could be applied to any other organism and any other type of habitat. The framework is obviously oversimplified. Nevertheless, it is useful for guiding decisions regarding the classes of habitat attributes to include in a method of detecting gains and losses of aquatic habitat and the coarse scale at which to measure them. It is also useful in explicitly identifying key assumptions whose examination is essential to the scientific rigor of the method and its adequacy for reaching the management objectives above.

Refinement of the term habitat is required because the term is often defined as where an organism lives or the physical, chemical, and biological features of the place where an organisms lives (Whittaker et al. 1977, Sly and Busch 1992, Stiling 2002). Such definitions may be satisfactory from vernacular and theoretical perspectives, but they are also open-ended and impractical from an empirical perspective because they fail to specify precisely what to measure. Their application requires specifying components of habitat that can be measured effectively and reliably, and these components may differ from one type of habitat, such as rivers and streams, to another, such as wetlands (Ford 2000).

Our conceptual framework consists of five elements considered at different spatial scales: the drivers of habitat change, landscape features, core measurement attributes, core response attributes to which fishes respond directly, and the presence of fishes (Fig. 1). The drivers of change represent general classes of processes believed to cause habitat or biodiversity alterations of large-scale concern. Examples include land use, climate change, acid deposition and invasive species (e.g. Sala et al. 2000). Of course, not every alteration within a class occurs over a large scale; however, the cumulative effects are of concern over a large scale. For example, within the land use category, an individual road crossing may have a minor effect on a stream, but the cumulative effects of road crossings throughout a watershed is a growing source of concern (Trombulak and Frissell 2000). Landscape features represent large-scale attributes that extend beyond the actual watercourse and include its drainage basin. Examples include the area of a watershed, land cover, and surficial geology. Some of these features, such as land cover, can be influenced by the drivers of change, such as land use. Core measurement attributes represent those features typically used to characterize aquatic habitat directly within, or immediately adjacent to, the watercourse. In lotic environments, these could include attributes such as flow, temperature, cover (including riparian zones), and connectivity. The drivers of change may influence these attributes directly, or indirectly through changes to landscape features. For example, climate change could directly influence stream flow via changes in the amount of precipitation. Alternatively, land use could alter stream flow through changes in land cover (e.g. deforestation) that influence the amounts and rates at which water enters the watercourse. Core response attributes represent those habitat features that aquatic organisms, such as fishes, perceive and respond to on a day-to-day basis. These would include features determining important biological processes such as habitat selection and reproduction. Examples might include water velocity, temperature, and predation risk. The features are perceived more locally by a fish's sensory abilities, possibly on the order of fish body lengths. Recording these over a fish's lifetime for a population of fish and quantifying their spatial distribution would provide the basis for an inventory of habitat supply from the perspective of the fish.

The framework provides the basis for making five significant points. First, for practical purposes the method of detecting gains and losses will need to be based on a set of **core** habitat attributes of general significance to the biology of all fishes. By definition, the core attributes will not represent all of the needs of every species. Thus, we are not proposing a comprehensive habitat supply approach and any effort to focus on particular species (e.g. endangered species) will require the acquisition of additional information, likely measured at additional spatial scales (Labbe and Fausch 2000).

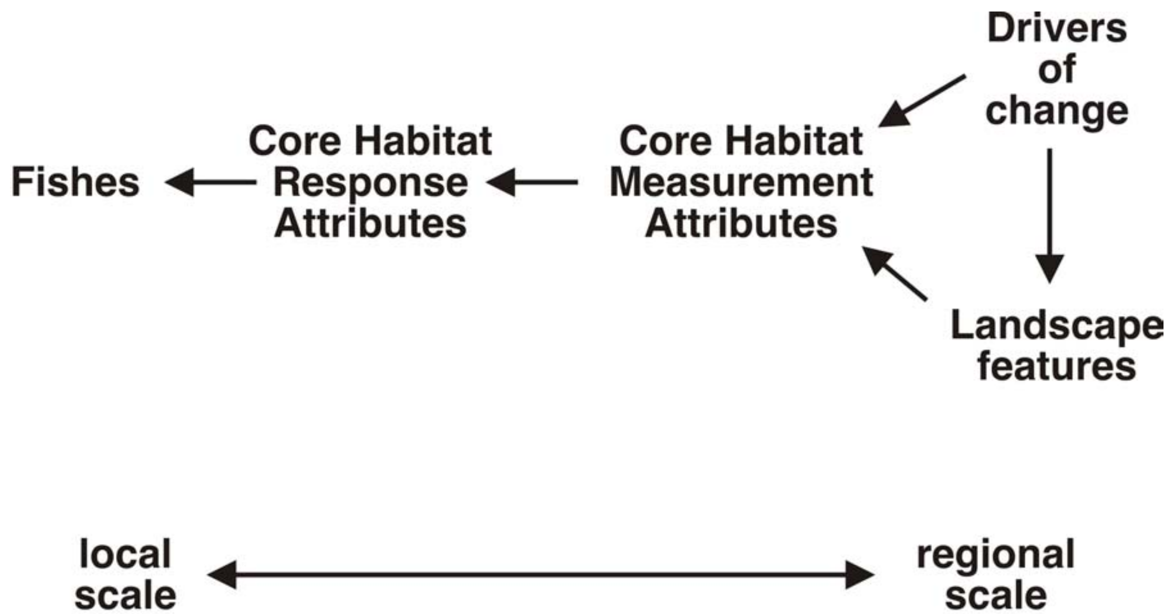

Figure 1.

Second, direct measures of aquatic habitat are preferred over indirect measures. Thus, the core attributes should be features within, or immediately adjacent to, a watercourse. Granted, changes in more extensive landscape features can influence habitat attributes within a watercourse and thus be used to predict the core attributes, however, the drivers of change may also act directly on the core attributes so any indirect approach of predicting core attributes from landscape features will need to be validated and justified. The distinction between direct and indirect measurement is important because the choice could influence how key measurements are made, e.g. monitoring gradients as with stream flow, or classification and inventory of types or classes as with land cover. A combination of the two may prove to be desirable in the end, however, some key Commission documents, including the Vision Statement, have been predisposed to the latter without clear justification and consideration of alternatives.

Third, the core habitat attributes will be aspects of the physical environment. This is recommended for practical purposes – measuring the biological environment adequately is not feasible. This is also reasonable because many changes in the biological environment may be indirect consequences of alteration of physical habitat. For example, physical alterations can facilitate invasion by non-native species (Refs). We recommend four general parts of habitat for measurement: water flow, structure, water temperature, and connectivity. These are widely believed to be important to fishes and there is general empirical support for their significance to the biology of fishes. Furthermore, they are practical to measure given the basin-wide perspective, consistent with the management objectives outlined above, likely to be measured by, or at least of concern to, management agencies around the basin. Water quality is a possible fifth part and is recognized in the Vision Statement milestones. We have not recommended firmly here because it may require very different field methods to sample.

The four core attributes have not been refined sufficiently here. For this reason, we have referred to them as general components of habitat. Further refinement is required to identify specific variables for each component and the appropriate spatial and temporal scales at which to measure these variables. This is potentially a significant challenge because of the numerous options. For example, the State of Connecticut's index of hydrologic integrity measures over 40 aspects of flow. The selection procedure for identifying specific measurements for each of the core attributes identified above could be initiated by conducting meta-analyses of the literature summarizing the usefulness (in terms of predicting the presence of fishes) and availability of measures developed to quantify the four core attributes of habitat (e.g. Fausch et al. 1988).

Fifth, the assumptions that the core habitat attributes are meaningful in terms of fishes, and in terms of the drivers of change, must be verified if the method of detecting gains and losses is to be based on the best science. This issue is important because some scientists have advocated a structural approach that focuses on the physical environment and implicitly assumes that biological requirements for the organisms will correspondingly be conserved. Yet, our perplexity with the way fishes respond, or fail to respond, to fabricated structures, such as fishways and bypasses (Mallen-Cooper 1994) reveals that our understanding of how fishes interact with their environments remains limited. The issue is also important because some functional classifications have developed conceptual approaches that seem well reasoned from a biological perspective, but not tested formally, possibly because of the feasibility of conducting the tests or pressing need to develop and implement some form of workable method. This skips the vital scientific steps of synthesizing the codified knowledge and, where appropriate, assessing the theoretical framework using data. In addition, this issue is important because the hierarchical nature of the habitat challenge favours an interdisciplinary approach and the extension and application of concepts across disciplines has risks as well as benefits. Fish ecologists have been more comfortable with research at the site scale and less so with larger landscape scales which has typically been the realm of hydrologists, geomorphologists, and geographers. In an effort to address the pressing habitat needs, there is a risk of habitat ecologists inappropriately applying principles and concepts from the physical sciences (i.e. concepts developed for different purposes) rather than developing a multi-scale theory of habitat from first principles that is rich and well formulated in terms of both biological and physical processes.

Quantification of Gains and Losses of Habitat

Estimation of gains or losses of aquatic habitat requires comparison of the observed value of some measure describing the quantity or quality of a habitat feature (Q_{obs}) for a site or watercourse with a corresponding reference measure describing the quantity or quality of the habitat feature (Q_{exp}) expected if the drivers of change were not operating (i.e. for undisturbed or least disturbed sites or watercourses) (Wiley et al. 2003).

$$\text{Gain (Loss)} = Q_{obs} - Q_{exp}$$

Three key components are required to make this calculation: specification of the habitat attributes of interest (the Q's), quantification of the current conditions (Q_{obs}), and estimation of the reference condition (Q_{exp}).

Watercourses vary naturally. It is therefore important to weigh any gain or loss against the normal range of variation for a river system of similar size and geographic location. One method proposed to accomplish this is normalization, where the gain or loss is divided by the estimated standard deviation in natural variability for the habitat attribute in question (Wiley et al. 2003). This transformation provides a z-score that expresses the gain or loss in standard deviations. Sites with scores of specified magnitude or greater can be identified as areas of concern and isolated for restoration.

Of the three components required to assess gains and losses, the first – specification of habitat attributes - was addressed above. The remaining two – quantification of current conditions and estimation of reference condition – are addressed in the following sections.

Approaches and Methods of Assessing Current Habitat Conditions

Addressing the Commission's habitat objectives requires the identification and inventory of riverine habitats. It also requires demonstrating that the core attributes used to measured habitat influence the distribution and abundance of fishes as expected. At the local scale (e.g. site), specific core habitat attributes directly affect fishes (Figure 1). These core attributes must be identified, and their relationship to fishes must be established, using a scientific approach. To date, the use of such an approach to identify core habitat attributes important to fishes in the Great Lakes basin has been limited. Local attributes may, in turn, be influenced by landscape features (e.g. surficial geology) at the regional scale (e.g. whole river, watershed) (Figure 1). Landscape features are usually more easily measured than local attributes (often using remote sensing or GIS techniques) and, if shown to be related to local attributes, may make the inventorying of riverine habitats simpler. Again, it is critically important that both the relationship between the local attributes and fishes, and then the local attributes and regional attributes, be rigorously tested before being used in any inventory.

No comprehensive inventory of riverine habitats in the Great Lakes basin has been undertaken. However, there are several ongoing projects that may lay the foundation for developing such a classification. Many of the projects are based on The Nature Conservancy (TNC) valley segment classification system. This system divides lotic waterbodies into segments based on a variety of criteria based on topography, surficial geology and barriers (Lammert et al. 1997). TNC assumes that each valley segment represents a distinct habitat. It is important to note that the landscape attributes used are thought to influence fishes (Lammert et al. 1997), but such relationships have typically not been tested. Several states (e.g. Michigan, Ohio), Lakewide Management Plans (LaMP), and the Great Lakes Aquatic GAP Project are using the TNC system to map known fish distributions, and to develop models to predict fish distributions. In essence, these models are testing whether or not valley segments actually represent distinct habitats that influence fish distributions. If the models have high correct classification rates, then they are likely incorporating attributes important to fishes. Similar projects are being undertaken in Canada by DFO and OMNR. A drawback to the TNC classification is that the attributes used to create the segments are fixed and cannot be defined by the user. An alternate segmentation method, ORSECT, has been developed by OMNR. ORSECT allows the user to choose what attributes are used to divide a waterbody into segments. In general, if the valley segments turn out not to be distinct habitats, they still may be useful as sampling units used in other methods.

There are many alternate approaches to identifying and inventorying riverine fish habitat in the Great Lakes basin. It may be classified by using attributes believed to be important to fishes (e.g. TNC valley segments, OhioEPA habitat quality indices), by using only fish data (e.g. IBI), or by using fish and habitat attributes together (e.g. CCA). The classification may be extensive (i.e. across the entire basin) or intensive (monitoring representative sites across the basin, e.g. EMAP). A gradient approach (e.g. CCA, fuzzy clustering) may be more appropriate than a classification approach. A comprehensive review of these alternate approaches is being prepared for publication (Piotr Parasiewicz, pers. comm.)

The appropriateness of these approaches may be evaluated using the following criteria:

1. Is it based on established relationships between habitat attributes and fishes? (i.e. based on first principles, underlying assumptions tested, peer reviewed)
2. Is it directly related to management objectives?
3. Does it have temporal sensitivity? (i.e. will it allow detection of gains and losses within the relevant time frame?)
4. Does it use a natural/virtual reference? (needed to measure past gains and losses, and to establish conservation/restoration goals)
5. Is it readily available?
6. Is it affordable? Is it cost effective?

Determination of the Reference Condition

The determination of reference conditions is challenging – conceptually and technically. It is challenging conceptually because many possible reference conditions can exist depending on the management objectives. For example, one could simply monitor changes from one point in time to another. In this case, the value of the reference condition at time t+1 would simply be the value of the observed condition at time t. Alternatively, one might specify the reference condition as the value of the habitat attribute expected in the absence of effects from all of the drivers (the historical state). Or, the reference condition might be the value expected in the absence of land use, under the assumption that habitat management to correct other drivers, such as climate change, is not feasible or realistic.

Determination of reference conditions is challenging technically because the information needed to define them is more difficult to obtain than the quantification of existing conditions. There are three possible sources of information for defining reference conditions and these are not mutually exclusive. The first is historical information, which is highly prized, but rarely available. The second is information on a nearby, "less-disturbed" watercourse. This is essentially using spatial variation as a substitute for temporal variation. It may not be satisfactory for drivers, such as climate change, that could influence all watercourses within a region. The modeling could be statistical. For example, a habitat attribute may be regressed against a landscape feature, such as % urban land cover. The reference condition in the absence of urban land cover could then be estimated by setting % urban land cover to 0. (There are well known pitfalls with making predictions of Y outside the measured range of X.) Alternatively, the model could be analytical in nature.

Reference conditions will need to be derived regionally. Watercourses can be expected to vary naturally from region to region due to geographic variation in climate, in-stream temperature, productivity, and geology. As such, some form of spatial clustering will be required to specify the regions and guide the selection or development of reference conditions for that region (Seelbach et al. in press).

The uncertainty surrounding quantification of the reference condition may be discomforting. However, specifying the appropriate reference condition is fundamental to all ecological assessment work (e.g. Underwood 1994, Peterson et al. 2001 , Wiley et al. 2003, Bailey et al. 2003). Moreover, it could be extremely valuable scientifically because key assumptions surrounding the definition of the reference and its relation to management objectives will be made explicit and open to criticism. Conversely, approaches where reference conditions are left implicit are more susceptible to the perils of changing or unspecified management objectives and creeping baselines.

Recommendations

1) The Commission's habitat milestone is achievable; however, the Vision Statement requires modification in two areas. First, the vision statement needs to add explicit management objectives that describe more precisely how the method of detecting gains and losses will be used, the time frame that updates will be required, and the spatial details of the habitats of interest. A corresponding document comparable to the Interim Policy on the Placement of Sea Lamprey barriers in terms of size, scope, and specification would also be helpful. Second, the milestones in the vision statement need to be reworded the to avoid any predisposition toward classification, so not to exclude potential alternative approaches to monitoring gains and losses of aquatic habitat.

2) The Commission is encouraged to define its role in habitat research within the basin more clearly. A logical and important role would be for the Commission to facilitate the development of a science-based, basin-wide perspective of changes in aquatic habitats to support decisions made at more local scales by partnering management agencies.

3) The Commission is encouraged to take a strong coordination role by supporting projects assessing the feasibility of integrating, summarizing, and evaluating habitat data collected by different management agencies. This coordination role is appropriate given that Valley Segment Classification is well underway in Michigan, Ohio, New York, and Ontario, as well as planned for Wisconsin. A habitat symposium at IAGLR would be a way to jumpstart this coordination process.

4) The Commission is encouraged to take a strong science leadership role by supporting projects and, as necessary, pilot projects (i) testing alternative frameworks (hypotheses) for quantifying aquatic habitats and assessing their gains and losses, (ii) examining key

assumptions of these frameworks, such as links between core attributes and fishes and core attributes and drivers of change, and (iii) developing frameworks for specifying appropriate reference conditions. It is recommended that these projects be carried out at temporal, spatial, and taxonomic scales appropriate for supporting the Commission's management objectives surrounding the quantification of aquatic habitat and the assessment of gains and losses of aquatic habitat. A worthwhile, initial project would be refinement of the core habitat measurements through meta-analyses of the habitat attributes available from the management agencies and the codified knowledge of their links to fishes and to drivers of habitat change (sensu Fausch et al. 1988).

Strong diverse views regarding the value of point ii remain. If the Commission does not consider testing the links between habitat attributes and both fishes to be a priority, then we suggest the term habitat be removed from the vision statement, because a link between the physical environment and organisms is implicit in its definition and interpretation. We also recommend the milestone be reworded to clearly specify the physical features that the Commission would like to see monitored. Lastly, we reiterate that the workshop participants strongly agreed that, from a scientific perspective, testing the adequacy of the links between habitat attributes and fish distributions was a needed and valuable part of developing a rigorous method of assessing gains and losses of aquatic habitat.

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Appendix 1. Research Workshop Agenda

Assessing Gains and Losses of Riverine Habitat in the Laurentian Great Lakes

Date: 20-21 August 2003

Location: Crowne Plaza, Romulus, MI.

Objective

This workshop sponsored by Great Lakes Fishery Commission (GLFC) will form the basis of a theme paper shaping the GLFC's research and funding priorities in the area of aquatic habitat, with specific emphasis on rivers and streams. The theme paper will assess whether the milestones identified in the GLFC's strategic vision are (i) achievable as written, (ii) unachievable, or (iii) partially achievable, but in need of revision. In the case of i and iii, the theme paper will address the conceptual and technological tools and advances needed to meet the achievable portions of the habitat milestones.

Format

The workshop will be organized as a facilitated, small group discussion addressing four general themes or questions developed in greater detail below. Within each theme, we will seek to summarize the state of the science and important knowledge gaps. To this end, we have tried to assemble a group that is rich and diverse in its expertise and to structure the workshop in a way that will encourage spontaneity and the creative injection and integration of ideas. The purpose of themes 1 and 3 will be to identify conceptual and technological additions that could advance the state of habitat science and be used to facilitate the GLFC's habitat goals. The purpose of themes 2 and 4 is to specify an important and feasible set of habitat research priorities for the Great Lakes and to outline the research needed to address these priorities satisfactorily.

Timetable (Times allocations are approximate)
Theme 1 - 8:30 - 12:00 AM, Wednesday, 20 August
Theme 2 - 1:00 - 4:30 PM
Theme 3 - 8:30 - 12:00 AM, Thursday, 21 August
Theme 4 - 1:00 - 4:30 PM

Theme 1. What are the pressing scientific questions in habitat research?

- Is there a unified habitat theory or framework?
- What are the different classes of conceptual approaches (e.g. functional vs. structural, top down vs. bottom up) and can they be unified?

- What are the key conceptual challenges or obstacles to carrying out habitat research? To achieving a unified theory?
    - Are previous schemes adequate?
    - Why then are there variations?
        - Have limitations with previous schemes been identified and documented adequately?
- Have alternatives to exisiting classifications been considered adequately?
- Is there a need to strengthen the scientific rigor of habitat research and, if so, what are the specific needs?
    - Are habitat classifications analogous to conceptual models?
    - Are predictions and assumptions identified explicitly? Tested adequately?
- Are the conceptual and empirical links between habitat and aquatic biota (in this case fish) important?
    - Do we know whether regional or landscape habitat indicators meaningfully reflect the local features we believe are important to fishes?
    - What are the key habitat attributes affecting fish distributions and abundances in riverine systems?

Theme 2. What are the key habitat concerns for riverine systems in the Laurentian Great Lakes?

- The management objectives for a method of quantifying habitat are elusive and varied. Do we need to we need to nail these down? How can we do this?
- What are the main causes of habitat change?
- Do the general forms of habitat change differ among these causes?
- Is an omnibus schema for monitoring various forms of habitat change realistic and feasible?
- Are there specific aspects of habitat change that are considered important and can be addressed effectively, expediently, and economically, given our discussion from theme 1?

Theme 3. What are the key technical issues surrounding the feasibility of carrying out large, regional habitat surveys?

- What general criteria (e.g. cost, time, coverage, precision) need to be met to ensure a project is feasible?
- What are the tradeoffs between these?
- What technological tools (or solutions) are available to overcome these challenges and facilitate habitat research?
- Is there a comparison or classification of these tools that is satisfactory in terms of its coverage, its assessment of the advantages and disadvantages

of each type of tool, and its consideration of complementarity among the tools?

- What tools would be useful to have, but do not presently exist?
- How feasible would it be to integrate data from different monitoring programs (e.g. carried out by different states or provinces)?

Theme 4. What would an application of the advances made in themes 1-3 look like when applied to rivers and streams in the Great Lakes?

- Can we devise a schema to inventory or survey riverine habitats? To detect gains and losses in a timely fashion, possibly against a background of variation due to natural change and measurement error?
- What would the key components be?
- What would the resource requirements be?
- How can we test the adequacy of the schema? What criteria would we use? At what points in the program would we assess these?
- Can we devise alternatives that could be compared?
- How might we compare their adequacy?
- Would pilot projects be appropriate?
- Is there a role for an adaptive management approach?
- Can the schema be carried out iteratively with timely deliverables and advances that satisfy funding sources? How?
- What is the optimal balance between getting some sort of survey done and conducting research testing the adequacy of the survey methods?

Venue: Crowne Plaza Detroit Airport, 8000 Merriman Road, Romulus, MI. Ph: 734-729-2600

Meals: Breakfasts, breaks, and lunches have been arranged at the hotel. Breakfast will be available in the workshop room. A dinner will be planned for the evening of the 20th.

Appendix 2. Habitat Workshop Notes

Vision:

→Assessment of Gains and Losses in Aquatic habitat

-Can we do this?

-What is involved?

-Interagency – Assessment

-How to Protect/Restore?

→Focus on entire riverine systems – Headwaters to lake

-balance between progress on inventory and testing links between habitat and fish production

→Integration of habitat into larger ecosystem context

-How to define habitat?

-Supporting science for key indicators

-Scales →Gains/losses at levels of ~ 1 km. (?)

→Scale defined by fish

→Over larger areas, level of detail decreases

→Need to identify attributed appropriate at larger areas

→Habitat losses →Function of cumulative losses

→Fish →Cue on very local stimuli and "assume" consistency

→Juvenile fish migrating downstream cue toward middle of river

→Need to consider habitat requirements for all species, not just salmonids

OEOS

→Identify all habitat features important to all species

→ Research/support links to fish (mechanistic)

→Inventory – all key attributes and gain/loss

→Need natural reference point for key variables

→Need to identify key variables

→Identify assumptions regarding reference of key variables

→"Virtual" reference – built from multiple sources

→Not just habitat volume/area →connectivity distribution is important

→Strategies:

- →Inventory human changes, seek area of low impact for reference
- →What would a stream look like if undisturbed by human intervention?
- →Map interventions (by type) →infer change in habitat from reference condition

→Reference needs to reflect current climatic conditions

→Reference points:

→Historical baseline (comparison)

→Desired future state

→Gains can be incremental?

Define Habitat

Piotr

Template →Place to live

→Structures – physical, biological, chemical

→Scale – varies

→Dynamics – space/time

→Quality

John

(Temp, DO)

→Hydrodynamic – physical

→Distribution of physical structures (not random)

→Translation of physical structures into hydrodynamic patterns

→How this information is packaged?

→Sensory systems needed to interpret this information (fish)

Mark

→Recognition needs of species and life stage

→Physical, chemical and biological requirements for survival

Kevin

→Restrict to physical components

→Usually what is assessed/mapped

Rob

→Theoretical concept

→Can't measure directly

→Represents life requirements

→How to operationalize is the question

→Likely multiple definitions

Chiadih

→Area where fish live

→Interplay between channel and flow characteristics

→Flow variability

Lee

→Ditto – Rob

→Need to identify components – how to measure

- →Set biological aside – habitat is for all species
- →Include chemical and physical

Hans

→Defines goals (species)

→All things that contribute to target

→Identify optimum/minimum for different attributes

Todd

→Include biological components

John

→Need to consider surrounding terrestrial areas – inputs to river systems

→Change in land cover over time

→Habitat Change

→Scale important consideration

Nick

→Physical, chemical and biological conditions that affect survival of species

Mike

→What fish need to live

→Riverine systems

→Flow

→Structure (hard, soft) refugia

→Temperature

→Connectivity

** discussion re including invasive species, water quality

** discussion of gradients as alternatives to structure

→Four classes – base layer

→Tiered approach to provide additional information to address specific problems – use these attributes to characterize reference conditions

→Water quality – needs to be added to list of components

→Flow and structure →Hydroscape

→Need to link species with physical reference

→Structure →Woody debris?

→Bank overhang?

→Non-embedded gravel

→These characteristics measured at different scales

→Flow, temperature, chemical – can be backcasted from landscape

→Link from these variables to biotic community – yes?

→Reference conditions – likely governed by large scale conditions

→Modifications to reference conditions may be at smaller scale

→Identify areas to show reference conditions

- →Target community species
- →Topography, geology
- →Overlay – look for intersections of characteristics of physical feature and community

→Criteria for virtual reference

- →Virtual reference – surrogate model for natural systems
- →Concept
- →Indicators
- →Test that it works at smaller scale
- →Integrate up to larger areas

→Identification of variables for assessment

→Method to identify reference condition

→Classification →Deviation of current from reference

→Methods to identify reference condition

→Qualitative analysis of historical physical conditions

→Qualitative analysis of fauna

→Comparison/grouping

1st Step →Comparison of estimated historical and current hydrographs - 41 statistical variables

→Significance to fish not yet known

(** This is the Connecticut model?)

→Mark Bain → Target community approach

→Literature →Potential species presence

→Identify similar rivers – physical and biotic

→Identify relative abundance of species (expectations) based on historical abundance

→Similar to IBI

→Rank species by relative abundance →expectation from proportional abundance

→Defines biological reference

Piotr

→For specific fish species →model of habitat attributes →estimate habitat proportions and compare with estimated species proportions

→Habitat graphs →Indicate habitat abundance over time (year)

→Done for most dominant species only

→Historical data regarding conditions

→Reference sites – conditions based on metrics – comparison across sites – to identify best conditions (space is a surrogate for time)

→Reference sites →based on models

Forms/Classes of Habitat Change

→Change in flow regime – time and space

→Change in sediment regime

→Change in bio-geochemistry

→Change in morphology i.e. channelization *

→Change in fragmentation – dams, culverts *

→(Invasive species)

→Removal of woody debris

→Change in temperature

→Loss of riparian vegetation

Mapping →Channelization

→Fragmentation

→Riparian vegetation

→Flow regime →model from changes in imperviousness and less forest cover

→Temperature →model from landscape – information e.g. surficial geology land use

→need basin scale tools now

→Many losses do occur at very small scales – this can not be ignored

→Tiered approach – partners with state/province agencies working at fine scales

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→Statistical survey approach – detailed monitoring of selected sites – represent basin in statistical sense - needs to be stratified

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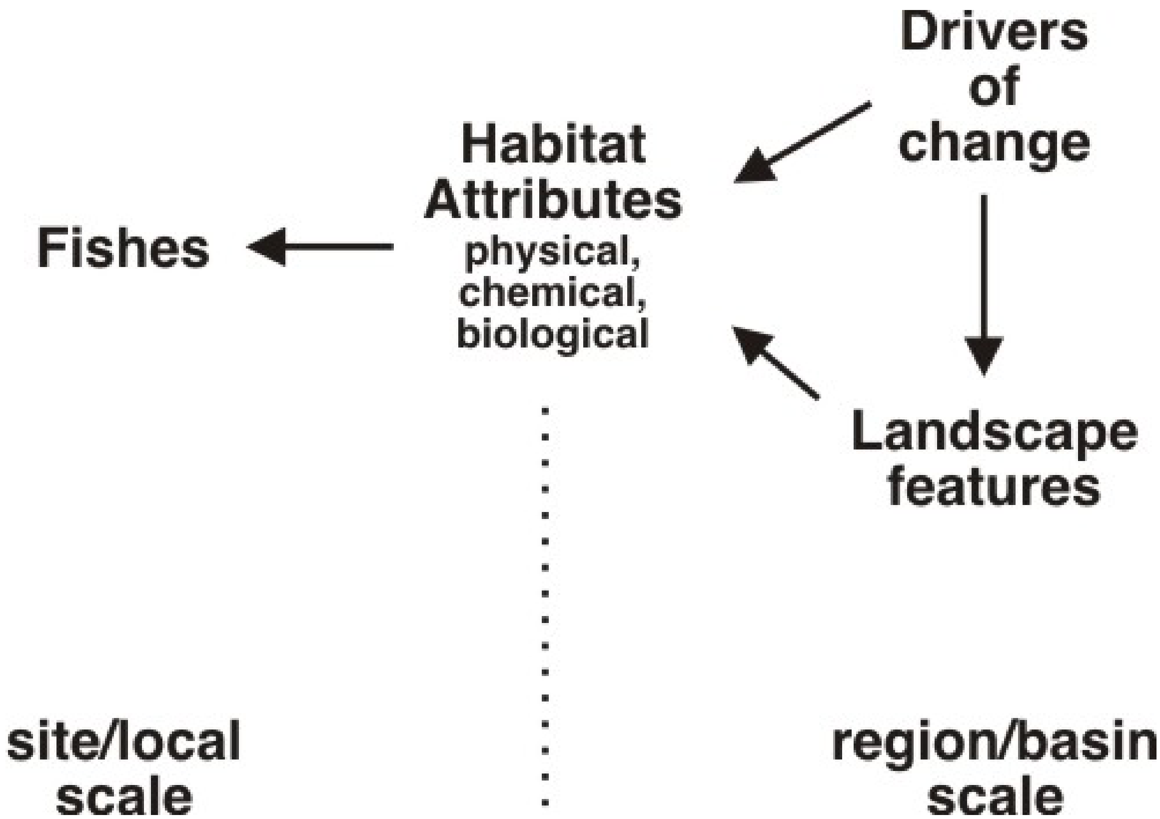
→Data sets needed for mapping – provides most of data needed to feed basin wide models


Drivers of change
Habitat Attributes
physical, chemical, biological
Fishes
Landscape features
site/local scale
region/basin scale

Approaches to Assessing Habitat Across Basin

→Mapping →Should begin with open architecture of attributes that contribute to structure/influence habitat

→Not “habitat” per se

→Need pilot project s in parallel to test relevance to fish

→Characterize tools according to options for application

→Same habitat changes/features suitable for mapping e.g. dams, channelization, riparian

→Others – require a different approach

→Evaluate approaches against attributes

→Scale

→Flexibility

→Defensibility

→Hierarchy of models

→Regional/watershed model →predict drivers for local scale model

→Habitat operates at a variety of scales – fine and large

Management Objectives
<u>Goals</u>

→Conservation of critical habitat

→Rehabilitation of degraded habitat

<u>Objectives</u>

→Manage endangered species through habitat management

→Improve understanding of habitat processes that support native communities

→Develop information system to identify habitat losses/gains, areas for rehabilitation, areas at risk

*Proactive/predictive capacity to manage watersheds

→Document extent of riverine fish habitat in Great Lakes Basin

→Identify important habitat parameters for fish - prioritize for assessment

→Identify measurement modeling efforts to provide details

*Protect and restore habitat that supports natural biological communities

→Inventory current land use

→Inventory core set of habitat attributes

→Verify linkage between **core** elements of habitat attributes and biota – fish species

→Multi-scale detection/backcasting/forecasting of habitat change to support management of land use (land cover)

→Identify areas – relevant natural

→Identify areas – for rehabilitation

→Identify areas – at risk/being lost

→Identify habitat potential

→Identify current condition

→Assess difference

→Develop reference condition for multiple sited/sizes of streams

→Coordinate tools – variability available

-Common delivery system

-Decision support system

→Develop habitat tool to support decision making

→Measures/templates of management problems

→Assessing feasibility/costs of restoration

→Establish – assessment framework to monitor progress over time a la suggestion by MLJones on day 1

→Need nested approach

→Tools →Lump parameters

→Process based

→Statistical model

Tools

Tools List – Initial

→IBI type assessment

→habitat indices

→IHA

→Remote sensing

-woody debris fields

-channelization

-stream/river structure/geomorphology

-bank, channel characterization, armoured vs. natural

-watershed/LS characteristics

-inventory, changes in land cover, riverine features/???word??

→Acoustic/LIDAR sampling

-sediment and substrates

-rooted vegetation

Possible Grouping of Methods

→On-ground inventory

→Modeling

→Remotely sensed

→Attribute of habitat models is taxonomic breadth

Scale

→Basin

→Region/Watershed

→Site

*Note: Pages 28 A and B

Nested Description

→Extensive - Intensive

→Survey	Subset intensively studied

Strategy for Assessment of Great Lakes Fish Habitat

1) Generic basin wide inventory of habitat attributes

2) Selection of sub-areas (watersheds, ecoregions) for intensive monitoring

3) Selection of sites with watersheds

   →Test/pilot sites, then expand

→Classification can only be done after establishment of baseline conditions

Process for Journal Paper   Ask the fish

→Methods used for HA are not linked to fish

→Theme paper could serve as thesis for paper

→Conceptual model and tools assessment important

→Managers primary audience – scientists also important

→Environmental Management (Oak Ridge)

→CJFAS – perspectives

→AWRA - Fisheries

Appendix 3. Habitat Workshop Participant List

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