Watters Mussel IBI 1991 Big Darby Creek

Grant Proposal

For Funding Through
The Nature Conservancy's
Rodney Johnson and Katharine Ordway
Stewardship Endowments

Title

Developing an Index of Biotic Integrity (IBI_B) for mussel fauna, with application for long term biological monitoring of mussels on the Big Darby.

Primary Investigator

Dr. G. Thomas Watters

Steward Submitting Proposal

Mary Huffman

Amount Requested

$ 2,000.00

Funding Through:

x RJ ____ KOSE

Budget Center to be Credited

B619000 - Big Darby Bioreserve

Regional Endorsement

Pending

Proposed Starting Date

April 1, 1990

Proposed Ending Date

June 30, 1990

Abstract:

The Ohio Chapter is trying to develop methods for long term monitoring of biodiversity in the Big Darby watershed. The proposed research will develop a biological metric of water quality assessment (a new index of biotic integrity) based upon the molluscan group of Unionidae, the freshwater mussels. Methods developed in this study are expected to provide cookbook procedures that stewards can use to monitor mussels and interpret information about the mussel fauna of the Darby at the community level.

Utilizing Unionids for biological monitoring will be an improvement over the current method of using fish communities for a variety of reasons. Unionids are long-lived and relatively immotile, providing a living monitor of a specific area over a long period of time, without the complications of fish migration. Unionids occupy only one trophic level and concentrate materials in their tissues from the immediate water column, not from several levels of prey. Unionids are easy to collect, identify, handle in the field, and return to the river without harm. Because of their durable shells, we can infer the character of mussel fauna long after the animals are dead, providing a temporal component to an IBI not attainable with fishes.

Grant proposal

Development of an Index of Biotic Integrity (IBI_B) for water quality assessment

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Introduction

The need for a biological metric of water quality assessment was realized in the past decade as it became clear that monitoring based solely upon physico-chemical methods was insufficient in some instances. Yoder (1989) has outlined the advantages of such a metric over non-biological methods. The most significant of these are a sensitivity towards long-term conditions and the ability to detect non-chemical impacts, such as sediment load.

This proposal suggests that a new biological metric of water quality assessment be developed based upon the molluscan group Unionidae, the so-called fresh water "mussels" or "clams." Justification for its development and implementation are given at length in the following sections. The metric follows the general conceptual framework of the Index of Biotic Integrity (IBI) designed for fishes (Karr, 1981, 1987; Karr *et al.*, 1986). However, original research (Watters, in prep a,b) indicates that the methodology currently in place for the fish IBI may be improved or replaced by the implementation of a different theoretical rationale. These new methodologies are realized in an IBI based on unionids.

The new methodologies to be employed are:

1) A bootstrap method determining ecoregions dependent solely on the taxa involved in the metric.

2) A recursive method of determining reference sites at any given level of stream size dependant on predicted diversity from species-area curve plots and unionid/fishes ratios.

The use of unionids as monitors has received surprisingly little study. This is in part due to problems in unionid systematics in many areas of the US. The index to be developed here covers only the Ohio River systems, exclusive of the Cumberland-Tennessee River drainages. This represents the most studied and best understood region of the US for unionid distributions. Its usefulness is thus limited to portions of IL, IN, KY, OH, PA and WV. However, if the index proves useful, it may be upgraded to include the Cumberland-Tennessee Rivers. The systematics of the unionids of the Atlantic and Gulf Coast drainages are too unknown (or misunderstood) to be incorporated into any distribution-generated studies, and distributions in the western Mississippi River drainages are only now becoming coherent.

Definition of terms

Several terms are used throughout this proposal, and their meaning here is defined:

EPA - U.S. EPA; state agencies are identified as such: OH EPA.

IBI_B - Index of Biotic Integrity, with unionid *bi*valves as the monitored taxon.

IBI_F - Index of Biotic Integrity, with *f*ishes as the monitored taxon.

unionid(s) - Members of the molluscan family Unionidae, commonly but incorrectly called freshwater "clams" or "mussels." This group does not include the fingernail or pill clams.

Justification

The use of the IBI_F has met with great success. The index has identified problem areas where physico-chemical monitoring and assays did not. The IBI is based upon fish diversity and counts of tolerant and sensitive species. All sufficiently diverse groups of animal and plant life are potentially useful as predictors of water quality, and fishes are almost certainly not the best among them. The bias for using fishes has several sources. Most freshwater biologists employed by federal and state agencies are necessarily well-acqainted with fishes because of the interest and revenue generated by both public and business concerns in fishery-related programs. Perhaps as important is the general public and business' pre-programmed disregard for animal and plant life that is not immediately of some obvious value to mankind. Finally, the IBI was originally developed for fishes. One of the developers of the IBI, Karr (1987: 251,252), gave an exhaustive (if highly biased) list of reasons for why fishes were the taxa of choice. The efficacy of using unionids may be judged by Karr's own criteria. Enumerated items below refer to Karr's original list.

1) "Life history information is extensive for many fish species ..." In this sense, Karr is referring to "life history" in its applicability to the IBI; that is, trophic levels, tolerance, and distribution. This information is also available for Ohio River system unionids. (All unionids are at the same trophic level *vis-a-vis* the IBI.) The life history is in some regards known to a greater extent for unionids than for fishes because of the motility of the latter.

2) "Fish communities generally include species that represent a variety of trophic classes..." Unionids, in one trophic level, are not equivalent to fishes in this regard.

3) "Relative to ... invertebrates, fishes are easy to identify ... [and] most samples can be sorted and identified at the field site..." I doubt that darters and shiners are easily identifiable to most workers, and although some unionids are also confusing, I believe that a similar amount of training will produce an equal amount of expertise in identification, whether it be unionids or fishes. Most, if not all, unionids may be identified in the field and returned alive.

4) "Evaluation of biotic integrity can be made very rapidly... no long-term laboratory work...is required" This is a restatement of item three above. Karr ends this item with a telltale nudge: "How many unprocessed invertebrate samples sit on laboratory shelves?"

5) "...Monitoring of fishes allows direct assessment of resource potentials that cannot be tested when other taxa are used in a monitoring program." This patently inaccurate statement is given with no justification. Clearly, any organism that occurs in a water body has the capacity to be effected by same and act as a monitoring agent. Why fishes, to the exclusion of *all other taxa*, are the only agents capable of doing so is not addressed by Karr.

6) "Both acute toxicity (missing taxa) and stress effects... can be evaluated." This criteria is more applicable to unionids than to fishes. As filter-feeders, unionids concentrate materials directly taken from the immediate water column. Fishes may accumulate materials also, but these may be derived from prey items from other (unidentifiable) areas. These prey items may have concentrated material from *their* prey, also of unknown origin, and so on down the food web. Thus, although fishes may bioaccumulate materials, it can never be known exactly where they contacted the material. In addition, because of the relative permanence of unionid shells, "missing taxa" are much easier to *positively* identify than are *presumed* missing fish taxa.

7) "Fishes are typically present, even in the smallest streams and in all but the most polluted waters." Unionids occur as far upstream as intermittent headwaters, the limit of fish distribution. Some species do not require fish hosts and thus may live in areas that do not contain fishes. Unionids, as sedentary animals lacking the motility of fishes to move elsewhere, also live in polluted streams. But unlike fishes, when they die they leave behind shells to indicate their former presence.

8) "Population and/or community data on fishes are already widely collected each year..." True, but unionids are also monitored, particularly with the advent of numerous species being listed as protected by state and federal governments. Furthermore, the immotility and longevity of unionids does not require as frequent sampling efforts as fishes.

9) "...fish populations are relatively stable during the summer, when most sampling activities occur." Karr refers here to the fact that fishes may migrate to spawn, thus giving inaccurate estimates of indigenous diversities. Unionids do not migrate, and sampling may be conducted at any time of the year.

10) "Fish species are primarily affected by macroenvironmental influences, while algae and invertebrates are more subject to both micro- and macroenvironmental influences." No evidence is given to substantiate this claim, and it is not clear why one should be more useful to an IBI than the other. Clearly microenvironmental influences may be overshadowed by macro influences. There is no reason to suppose that fishes are less susceptible than unionids to "microenvironmental influences."

11) "Fishes are relatively long-lived and thereby incorporate temporal integration into assessment of stream conditions." Unionids, depending on the species, may live over a 100 years. Most live between 10-30 years, and thereby incorporate even more "temporal integration."

The previous list was not meant to be a castigation of Karr's enthusiastic support of fishes, but rather to be an illustration of the fact that the same criteria used to select fishes as a biological monitor apply at least equally well to unionids.

In many circumstances, unionids may be as good as or better than fishes as biological monitors. To summarize, unionids are immotile and long-lived, thus providing a living monitor of a specific area over a long period of time, without the complications of seasonal migration. Unionids occupy only one trophic level. They filter water for food and respiration. Materials concentrated in their tissues are derived from the immediate water column, not from several levels of prey from untraceable locales (in addition to respiratory intake). If unionids die or are effected otherwise by contaminants, there is no question as to where they contacted such materials. By virtue of being on a single trophic level, they are readily comparable between themselves while mixed trophic levels introduce nonanalagous comparisons. Unionids are generally easily collected and require no special equipment in most situations. They are as easily identifiable to trained personnel as are fishes to equally trained staff. Unionids may be held out of water for much longer periods of time than fishes, and handling them does not stress them or effect their survival when returned, so far as is known. They occur from the smallest tributaries to the largest rivers and display distinct faunal assemblages identifiable with river reaches. Because of their durable shells, a fauna may be inferred long after the animals are dead. This introduces a temporal component to an IBI not attainable with fishes.

Other metrics besides the IBI_F exist to measure the biological potential of water quality. The QHEI (Qualitative Habitat Evaluation Index; Rankin, 1989) evaluates systems based upon hydro- and geophysical parameters, and thus has a temporal component. As a non-biological metric (strictly speaking) its correlation with biological methods is of prime interest. Its relation to an IBI_B measure may be more revealing than its relation to an IBI_F because of the motile nature of fishes, and comparison of IBI_B values with known QHEI values will be an important procedure in the planning phase of the IBI_B.

An additional metric, the ICI, uses macroinvertebrates (OH EPA, 1989). Unionids are not used, although fingernail clams are (Sphaeriidae). The metric makes the greatest use of aquatic insects, most in their immature stages. Because the majority of these insects will metamorphose into non-aquatic adults, this assessment is highly dependent on seasonal fluctuations that initiate this change. Unionids metamorphose from their fish hosts, but thereafter do not move any considerable distance.

The proposed index could be used in conjunction with established IBI_F and other metrics. The proposed IBI_B may be able to detect water quality problems transparent to other assessment methods, or detect difficulties at an earlier stage. The implementation of the IBI_B can only increase the reliability of biological monitoring by strengthening the weight of all assessments, regardless of method. It also adds flexibility to any management program by introducing a new area of expertise, malacology.

Proposed methodology

The IBI_B will follow the conceptual framework of the IBI_F. Intolerant and tolerant species will be chosen based upon field experience and compared with those chosen by current methods (OH EPA, 1988). The metrics scoring trophic levels would not be used. The main points of departure from standard methods are the following: criteria for selecting ecoregion and criteria for selecting references sites.

Criteria for selecting ecoregion

Current methodology employs a ecoregion/regional site approach based on (in OH) five ecoregions. Although the rationale behind the recognition of these ecoregions takes into account many important factors, the possibility of spurious assignments exists, at least for unionids. For example, current practice places the Maumee River in its own region in Ohio. The fauna, however, is derived from the Wabash River (Underhill, 1986; Watters, 1988). That river is more like the Muskingum and Scioto Rivers and should be included with them. There is evidence that although portions of the Muskingum and Scioto Rivers lie across two or more ecoregions, the rivers form a cohesive unit unto themselves in Ohio (Watters, in prep b).

A bootstrap method may be used to delineate ecoregions based upon the variables of interest, *i.e.* the animals themselves. It is proposed that varimax factor rotation of river system faunal diversities is better able to "choose" comparable regions. These regions correspond to factors and are internally homogeneous. A listing of each factor and its river systems would enable the selection of comparable areas for reference sites to be made with greater precision.

Criteria for selecting reference sites

Based upon the selection of a ecoregion by the above method, the selection of the reference site follows the species-area method of current practice, but with some differences. The use of the species-area curve is central to several variables of the IBI_F for scaling purposes. However, the curves must be defined for each ecoregion (Watters, in prep a), not for sampling techniques. The curves of one region are not comparable to those of another. Furthermore, the demarcations between scaling regions cannot be construed as straight lines. The species-area curve itself is composed of numerous curved segments following a power function, semi-log function, linear function, or Coleman function curve (Dony, 1977; Connor & McCoy, 1979; Coleman, 1981; Watters, in prep a). Each ecoregion must be assigned a "best fit" curve for realistic reference sites to be chosen.

The Upstream-downstream Reference Condition

This reference condition (EPA, 1990:28) has been implemented in situations where "habitat characteristics of the waterbody above the point of discharge are similar to ... the stream below the point of discharge." This methodology has a unique source of error that has not been addressed, particularly for measuring the IBI_F. Data based on unionids unequivocally document major faunal shifts over short river reaches without a noticeable change in habitat characteristics. Studies of Fish Creek of the St. Joseph River in IN, MI, and OH (Watters, 1988b) revealed a change of dominant species over a stretch of several miles such that upstream and downstream faunas were essentially incomparable. Because the distribution of the unionids in the stream is the direct result of their fish hosts, clearly some phenomenon relating to fish distribution has occurred that may not be identifiable on a year round basis. Thus, depending on time of year and choice of sampling stations, the upstream-downstream reference sites may actually be comparing unrelated faunas, and consequently generating erroneous conclusions.

The use of an IBI_B would enhance the possibility of detecting such faunal shifts. As unionids are essentially immotile, they are not susceptible to sampling error due to spawning and migratory habits, and are available year round for monitoring. The durability of shells adds an historic element, if needed, to the database.

The development of the IBI_B will include the following:

1) Recognition of tolerant and intolerant unionid taxa.

2) The forming of suites of comparable river systems based solely upon their faunal similarities. This will use the varimax factor analysis to identify these regions.

3) The selection of reference sites based upon a new implementation of the species-area curve. Curves will be generated for each of the ecoregions established in 2 above. Each curve may be broken down into scaling factors as in current methodology.

4) The generation of the data base necessary to accomplish the above steps. Data will be obtained from all available literature sources and records of selected museums.

Expected results and reports

The final IBI_B will be of a diagnostic level equal to the current IBI_F. Its implementation by staff and researchers will be simplified as much as possible because mathematical background and computational methods will be transparent to the end user. Two reports will be issued.

1) The conceptual background of the project. This would include all methodologies used to arrive at the metric, such as justification for the computational and theoretical measures chosen. Additional

information to be contained: all data bases; all statistics; extensive references; comparsion with existing metrics on a site by site basis.

2) The manual. A step by step guide to implementing the metric, demonstrating how to select the proper ecoregion (from a list), the correct reference sites (from accompanying figures), how to arrive at scaling factors, and how to calculate the final metric.

Appendix A:

References

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Appendix B

Budget

Salary, for three months	$ 8000
Assembling data, includes museum fees	$ 2000
Total	$10000

Amount sought from TNC .... $ 2000
Matching funds
US EPA .... $ 4000
Ohio River Mussel Trust Fund .... $ 4000

$ 7000 will be requested for start-up

Appendix C

Time schedule

1990, reports finished three months after funding approved.