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BIOMAK: A Citizen Guide to Biological Monitoring and Assessment of the Kayaderosseras

Introduction:

Since the Clean Water Act was implemented in 1972, water quality has improved across the United States (EPA-CWA). However, the vast majority of our Nation's waterways continue to be degraded and require closer observation. As of 2004, 44% of streams, 64% of lakes and 30% of bays and estuaries were classified as "impaired" under Clean Water Act standards (CWA-Webcast). These statistics are predominately due to the Clean Water Act's limited ability to legislate policy change for non-point source pollution. This form of aquatic pollution is difficult to identify and can be equally as challenging to rectify as it derives from diffuse, indiscrete sources including acid rain, excess fertilizers and pesticides from agricultural and residential runoff, toxic chemicals from urban areas, salt from roads, improper irrigation practices, as well as bacteria and/or nutrients from animals and faulty septic systems (EPA-Basic). Non-point source pollution is largely anthropogenic and has the ability to significantly alter aquatic ecosystems as well as degrade potential drinking water and recreational facilities.

Nationwide water quality protection and monitoring is resource intensive in terms of both manpower and available capital. The responsibility falls upon the EPA (Environmental Protection Agency) to maintain sufficient water quality standards essential for human health as well as environmental health. This is attained by delegating responsibility to smaller programs including The Office of Water (OW), which is charged with the implementation of the Clean Water Act, along with the Safe Drinking Water Act and other acts that have proven to be successful steps towards the improvement of nationwide water quality (EPA-NWP).

In New York State, the DEC (Department of Environmental Conservation) continues to monitor water quality with a variety of programs and initiatives. As with the rest of the nation, New York's surface waters continue to suffer from increased contamination from non-point and point source pollution, resulting in the loss of aquatic

ecosystems that not only serve as natural filtration, but also as buffer zones between more and less polluted areas. New York efforts to improve water quality consist of the Rotating Integrated Basin Studies program (RIBS), the Stream Biomonitoring Unit, the Lake Classification and Inventory, Citizens Statewide Lake Assessment Program, and the Groundwater Sampling Program. These initiatives serve to monitor water quality and compile data to aid analyses (EPA- Programs).

The DEC aims to monitor drainage basins across the state every five years, including the identification and documentation of both problematic and positive examples of water quality in the state. As part of this endeavor, the RIBS mission is to "identify long-term water quality trends, characterize naturally occurring or background conditions, and establish baseline conditions for use in measuring the effectiveness of site-specific restoration and protection activities" (EPA-RIBS). The task of accomplishing this mission as it applies to over ten thousand waterways statewide is extremely demanding considering the current limitation of government resources. The RIBS initiative uses biological monitoring, or the analysis of ecosystem health through living organisms, as a screening process to identify problem sites for more intensive monitoring. In order to provide more accurate and detailed information regarding water quality as it pertains to that water body's function, RIBS uses multi-media sampling techniques incorporating water chemistry, bottom sediment and invertebrate tissue chemistry, toxicity testing, macroinvertebrate and fish community assessments and habitat evaluation.

Working alongside the RIBS initiative is the Stream Biomonitoring Unit (SBU), a program that was initiated by the Federal Water Pollution Control Act Amendments of 1972. SBU works by assessing macroinvertebrate communities to determine water quality. Similar to the RIBS initiative, the SBU also uses macroinvertebrate tissue samples to obtain information on toxin levels (DEC-SOP).

Biological monitoring (or biomonitoring) is becoming a more prevalent tool in the assessment of anthropogenic and environmental impacts on surface waters (Lange, 1995). In many cases, the health of a biological community is directly correlated with the health of the environment in which it dwells, and can therefore act as an indicator of general ecosystem health (Karr 1999). Simply put, biomonitoring is the assessment of biological

responses to changes in the environment (Bode, 2004). In our case, benthic macroinvertebrate assemblages are monitored to aid in the analysis of stream health. Benthic macroinvertebrates are organisms that lack a backbone (invertebrate), spend at least part of their life at the bottom of a water body (benthos) and are large enough to be detected by the naked eye (macro), the latter making them ideal candidates in studying stream health (Bode, 2004). Benthic macroinvertebrates, including insects, worms, mollusks, and crustaceans, can be sensitive to pollutants, making their community sizes or mere presence valuable tools in the assessment of stream health (Bode, 2004). In addition, macroinvertebrates provide a temporal analysis of stream health as organisms are constantly exposed to their habitats and are therefore more greatly affected by them. Since the SBU was initiated in New York State in 1972, it has been successful in making use of macroinvertebrates as indicators of contamination and water quality. Biomonitoring is an engaging experience and is constructive in the inclusion of local citizens with their natural environment. Because biomonitoring has minimal time and equipment requirements, it is ideal for community science programs.

With all this in mind, we decided to create a citizen-based guide to macroinvertebrate biological monitoring to both foster a deeper connection with nature as well as supplement limited government monitoring resources. Although chemical analysis might give more precise data compared to biomonitoring, we did not choose this method for our project for practical reasons. Necessary chemicals and processing equipment are expensive, potentially unsafe if handled improperly, and are not easily accessible to the wide range of citizens that we hope to address in our effort. We could not feasibly distribute chemicals the way we can provide information regarding biotic organisms. In addition, chemical testing would only provide a snapshot of the water quality at one point in time. Because macroinvertebrates are continuously exposed to the pollutants and nutrients in their environments, they are valuable in the assessment of changes in long-term water quality by the analysis of their density and distribution. With this idea in mind, the macroinvertebrate community population changes could provide a warning system for stream pollution or degradation (Odum, 1971).

This long-term analysis of water quality is extremely beneficial to data interpretation and the targeting of problematic waterways, which could potentially help

supplement government data collected by RIBS. While chemical analysis can sometimes provide more concrete data, our project includes the involvement of citizens of all ages and chemical use could potentially be hazardous to younger candidates, deterring future involvement. By creating an easily accessible view of the biotic world, we hope to encourage a closer relationship between citizens and their natural environment. We believe that there is no better way to accomplish this than to work and be in the natural world. Biomonitoring is more intuitive, user-friendly, and would attract a wider audience than chemical water testing. Ideally, future citizen monitoring practices could integrate both chemical and biotic components of analysis to provide a more complete view of stream health.

We believe that water quality is not static and should be monitored more than once every five years as the RIBS initiative currently implements, especially since this task currently falls upon only two government employees. With this in mind, the inclusion of community members could serve as a valuable resource in the data collection process. The availability of water quality monitoring resources is similarly inadequate across the northeast and, as a result, several states have already implemented volunteer-based biomonitoring programs. Virginia, New York, Pennsylvania, and the EPA signed the Chesapeake Bay agreement in 1987, promising the protection of the bay's natural resources from human activity-related degradation. In order to keep track of contamination and disturbances, the agreement called for local stream monitoring to assess changes in water quality. The sheer number of streams among those states (100,000+) hindered monitoring agencies' attempts to effectively and efficiently monitor the entire area (Nichols, 1992). Virginia was one of the first states to receive the EPA's approval for a volunteer-based monitoring program (Gowan, 2007). In collaboration with the Izaak Walton League of America, the Virginia Save Our Streams program was formed, which uses cost effective methods to monitor water quality and raise awareness of human impacts on surface waters (Firehock, 1995). Similar attempts to include the local community in biomonitoring assessments have been implemented in other watersheds and have proved useful in the collection and analysis of water quality data.

Another citizen stream program is currently being implemented in Ohio as part of the states' Scenic Rivers Program, in which junior high school students complete most of

the monitoring. Teachers in the area have jumped at the chance to teach stream ecology and activism with the Stream Quality Monitoring Program (SQM). Illinois now uses a similar program, having recognized the value in an educational protection initiative. Other states including Massachusetts, North Carolina, and Kentucky also have citizen stream monitoring programs (McDonald, 1991). In addition, Connecticut has started a volunteer-based monitoring program in cooperation with the existing River Watch Network. As of 1995, twenty-seven state regulatory agencies use volunteer-gathered data in reports to Congress (Penrose, 1995).

Jennifer Lough Fuller (2007) explored the mechanical and instructive aspects of stream biomonitoring methods for educators and citizen monitors in Alabama. Her efforts focused on increasing accuracy in citizen-based analysis compared to trained science professionals'. This goal was successful and increased maximum accuracy from 53% to 60% by modifying their protocol to better guide citizen science members, (Fuller, 2007). In an evaluation of community based monitoring, the main problems were separated into three groups; organization, data collection, and data use. Without organization, interest and information, any data collected will most likely be inaccurate and unreliable by government standards (Conrad, 2010). Another community based monitoring experiment based in Mexico found that training community members to monitor water quality by collecting data with standardized, simplified and less expensive methods allowed for more sampling over a greater area (Campbell, 2007). Yet another study focusing on the Virginia Save-Our-Streams program demonstrated that volunteer initiatives could produce valuable and accurate data if every protocol of standard methods was followed (Engel, 2002). The creation of a citizen guide could potentially standardize the science of biomonitoring at a community level, produce viable data to help supplement the RIBS initiative.

Many organizations and communities could benefit from this amalgamation of professional scientists and local citizens in the Saratoga Lake Watershed including the Friends of the Kayaderosseras, Saratoga Lake Association, Trout Unlimited, Clifton Park and local boy-scout troops. In Saratoga County 2.14% of stream and river segments and 0.07% of ponds and lakes are classified as impaired, making continual monitoring all the more relevant (USGS, DEC 303-D). The Friends of the Kayaderosseras organization's

mission is to promote awareness and appreciation while fostering a mindset geared towards conservation and protection of the Kayaderosseras Creek. The Friends are currently looking for a program to unite people of all ages with the creek and surrounding environment. In this respect, a community-based program focused on the creek's ecological health would both foster a community spirit and could be beneficial to stream technicians looking for volunteers (Friends of the Kayaderosseras).

We created a volunteer biological monitoring guide, BIOMAK (Biological Monitoring and Assessment of the Kayaderosseras Creek), with the intention of not only aiding in the efficient accumulation of water quality data, but also of involving families in an educational process that could help inspire future initiatives in the appreciation of nature. The citizen BIOMAK Guide could serve as a positive learning tool for teachers and would be fairly easy to implement into already existing curricula. Children exposed to nature at a young age are more likely to develop a stewardship and conservation-based relationship with nature later in life (Athalie, 2002). We have designed a sampling plan that mirrors the DEC and RIBS initiative by the development of the citizen BIOMAK Guide for local organization members with the hopes that data collected by citizens will be integrated into the existing government water quality database.

Guide Design:

In the design and creation phase of our Citizen BIOMAK Project, we reviewed past water sampling techniques and guides from the EPA and DEC, as well as other citizen or volunteer-based science projects in order to best implement the community members in our project, as citizen-based biomonitoring has proven to be successful in other studies (Fuller, 2007, Campbell, 2007). As a general baseline for our methods, we used the DEC's manual on Stream Biomonitoring (DEC-SOP). Mimicking the DEC sampling procedures should foster compatibility between our project and the RIBS initiative, allowing our data to be used in conjunction with DEC data. In order to ensure the quality of citizen-gathered data, BIOMAK will require the presence of a certified taxonomist on sampling days. The Hoosier Riverwatch training manual, based out of Indiana, also served as a valuable design template for BIOMAK.

We worked in close collaboration with Blue Neils, A.J. Smith, and Larry Woolbright , who are members of the Saratoga County Intermunicipal Stormwater Management Program (ISWM), the New York Department of Environmental Conservation, and Friends of the Kayaderosseras respectively. These contacts were maintained throughout BIOMAK's design in order to ensure we were using the most effective methods to incorporate both the community and scientific aspects in our project. Through meetings and interviews, we successfully gathered what they believe is the most important information to convey to the public, as well as ascertained the information needed to be helpful in water quality monitoring. We also used these resources to help organize a volunteer network of citizen scientists, along with the necessary trained professionals.

A.J. Smith was able to give us access to the DEC random probabilistic sampling sites to use as suggested sampling areas in BIOMAK. In addition to these pre-selected locations from the DEC, we selected other historically sampled sites. We also included some areas of particular interest to environmental organizations. We chose water quality critical areas along the Kayaderosseras Creek that could be accessed by organizations and citizens interested in participating. These sites were chosen based on accessibility and characteristics of the specific sections of the creek. Specifically, we looked for shallow areas that have substrates with at least a modicum of stability.

Because of the time-consuming nature of monitoring water quality, like other projects, we found it important to make use of community members to supplement professional workers. In order to make the data gathered from citizen-participated samplings valid, we designed our citizen guide, BIOMAK, to educate the public and connect them with the necessary taxonomists. BIOMAK functions along the same lines as the DEC water quality sampling techniques to ensure the data can be used by the DEC as well as other interested parties with the presence and assistance of a certified taxonomist.

BIOMAK is broken into five main sections. Chapter one explains what BIOMAK is, why biomonitoring is important, and explains general information about macroinvertebrates. Also included is a list of required and optional equipment and safety tips. Chapter two involves the procedures of biomonitoring; site selection, physical characteristics, and the two types of net sampling techniques. Chapter three deals with

macroinvertebrate identification, and has cards containing general characteristics, size and a photo of each order or phyla of water quality importance. A one-page break down of all macroinvertebrates is also provided. Chapter four is composed of a sample data sheet, with numbers and macroinvertebrate tallies filled in to represent what a data sheet would look like in the field. The last section amounts to the appendices, accounting for a map of the DEC random probabilistic sampling sites, contact information, equipment purchasing information and references. These five sections of BIOMAK were laminated and spirally bound to make the manual field-durable. In addition to this, multiple copies of the simple macroinvertebrate key and the data sheet were provided on waterproof, tear-resistant paper, located in a folder at the very end of the guide.

To conclude our project, we selected a focus group with the help of the Blue Neils and Friends of the Kayaderosseras in order to preview our Citizen BIOMAK Guide. This gave us both citizen and scientist feedback and showed us the holes and challenging parts in our guide, while still allowing sufficient time to make the appropriate adjustments to the BIOMAK Guide.

Discussion of Guide Design and Implementation:

After the completion of a polished draft of our Citizen BIOMAK Guide, we distributed our guide among the Friends of the Kayaderosseras and other potentially interested citizens. This was completed to get detailed and honest feedback from environmental activists and/or engaged citizens. Theoretically, these persons may be an organizational head, or even a citizen monitor, so it was crucial to make our procedures, objectives, and information as clear and concise as possible. In this way, we expected to see the parts of our guide that would benefit from further clarification, and still had time to make the proper adjustments.

The major distribution took place on April 16th during the Trout Restocking Day run by the Friends of he Kayaderosseras. Originally, this was also going to be our trial run of the guide, but weather conditions and permit issues stalled this attempt. The trial run was going to take place so late in the design process because macroinvertebrates hibernate during the colder winter months, and waiting till this date ensured a more

diverse macroinvertebrate assemblage. In addition, a later start date theoretically allowed for a warmer, more comfortable environment for collectors.

Before any major macroinvertebrate sampling event, we would recommend the test run of the guide so as to be absolutely sure the procedures and information are as clear as possible for the widest range of possible citizen volunteers.

Conclusion:

The ability to maintain water quality starts with the identification of impaired surface waters. In New York State, this task is currently operated by two government employees of the RIBS initiative, who monitor all NY water bodies on a five-year, rotating basis. Water quality is constantly in flux as pollutants and nutrients cycle through aquatic ecosystems, degrading habitats, recreational facilities and drinking water opportunities. In other words, we believe that five years is too long to be monitoring our world's most valuable resource. To help supplement government water quality data in the off years, our project, Citizen BIOMAK, proposes that community volunteers could potentially serve as valuable sources in the collection of water quality information. Data collected by citizens could help target problematic waterways, while also providing an engaging experience in nature. Local organizations, such as Friends of the Kayaderosseras, would greatly benefit from a program that encourages volunteers of all ages to become more involved with the protection of their surface waters. By creating the Citizen BIOMAK Guide, we are creating a more feasible opportunity for community members to perform Biological Monitoring that is up to DEC standards.

Upon completion, BIOMAK will be given to Blue Neils, who will act as a project coordinator in organizing citizen monitoring events. BIOMAK can also serve as a model for future citizen-based macroinvertebrate monitoring guides. The layout of the guide acronym even allows for easy transfer to other watersheds (e.g. BIOMAD for the Dwaas Kill Watershed). Hopefully, BIOMAK will serve as the foundation to increase citizen involvement and water quality monitoring throughout the Saratoga Lake Watershed, as well as providing a valuable framework beyond that specific reach.

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