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Volunteer Environmental Monitoring and the Role of the Universities: The Case of Citizens' Environment Watch

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ABSTRACT / Universities can provide a stable home for launching collaborative community research projects. Citi-

zens' Environment Watch (CEW), an environmental monitoring initiative based at the University of Toronto, has made significant contributions to environmental education and stewardship in Ontario, Canada. Following dramatic cuts in provincial monitoring programs, citizens and youth have used chemical parameters and biological indicators to gauge water and air quality, and to identify areas requiring remediation and pollution prevention efforts. The relationship of Citizens' Environment Watch to government agencies, funders and other grassroots environmental groups has evolved over the past 5 years as CEW attempts to remain effective without taking on the investigative and enforcement roles to support the regulatory enforcement that has been largely abandoned by government. We explore the challenges inherent in developing and maintaining a volunteer organization that carries out rigorous and useful scientific work and we outline the ability of a university to help overcome these critical challenges. Finally, we present lessons learned for the benefit of other citizen and youth monitoring projects.

Since the early 1960s, the public has grown increasingly aware and concerned about the environment. In virtually all nations of the developed world, governments responded by establishing national, provincial or state ministries responsible for environmental protection and regulation. These departments assumed the scientific and legal responsibilities of environmental monitoring and regulation. Simultaneously, governments recognized citizens' desire for a role in environmental stewardship and decision making (Cantwell and Day 1998, Landre and Knuth 1993). Until this past decade, Canadian government, particularly provincial governments, have assumed primary responsibility for environmental monitoring, regulation and protection. Since 1996, however, severe cutbacks in the Ontario Ministry of Environment budget and staff (Krajnc

2000) have affected the government's ability to track and respond to environmental change to ensure the protection of both human and environmental health (Canadian Institute for Environmental Law and Policy 1999, Ontario Public Service Employees Union 1997). This well-documented withdrawal of the state from environmental monitoring and the move towards voluntary approaches to pollution and environmental management (Gibson 1999) has led to a decrease in the number of routine government investigations and prosecutions, particularly with respect to water quality (Donnelly and others 2001, Molot and others 2001).

At the same time, community-based research (CBR) "conducted by, for or with the participation of community members" has grown. "More often than not, community-based research involves the collaboration of community members (represented by grassroots activists, community-based organizations, etc.) and experts (represented by university researchers and professional scientists.)" (Loka 2001). CBR projects usually link citizens' groups with university experts, permitting collaborative research that is both credible and relevant,

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while drawing on valuable local knowledge (Mackinson 2001). Though the practice of CBR presents many difficulties (Israel and others 1998), it can provide a good model for launching and maintaining environmental monitoring projects, especially when quality assurance and quality control are fundamental to success.

This paper examines the role of community-based research and volunteer monitoring in responding to the withdrawal of government from environmental monitoring. In particular, it reports on the experience of one group, Citizens' Environment Watch (CEW), based at the University of Toronto, which has monitored surface water quality in Ontario, Canada since 1997. In this context, we pose a number of questions and discuss the issues they raise: Can citizen-collected data be used not only for environmental education but also to promote environmental protection, pollution prevention and habitat rehabilitation? What kinds of data best serve these goals? Can a strong university base for grassroots monitoring groups help to address these challenges?

Background

While this paper does not seek to provide a comprehensive summary of volunteer monitoring efforts, it is important for the context of CEW's experiences to briefly touch upon some of the developments in volunteer environmental monitoring in North America. Once a marginal activity, volunteer monitoring of rivers and lakes is now a widespread endeavor; citizens across the continent have taken an active interest in their local water quality. Perhaps the strongest evidence of this increasing commitment to local environmental stewardship is the dramatic rise in the number of grassroots environmental monitoring groups throughout North America (Griffin 1999). The United States Environmental Protection Agency (USEPA), a key supporter of volunteer monitoring efforts in the United States, currently lists over 700 programs in their *National Directory of Volunteer Monitoring Programs*. In response to this extensive participation, the USEPA publishes "The Volunteer Monitor," a biannual newsletter, maintains a list of volunteer monitors, provides community groups with up-to-date manuals, directories and other resources, and also sponsors workshops and conferences for community-based water quality monitoring programs (USEPA 2002).

In the last 20 years there have also been a growing number of university-community partnerships. Throughout the United States and Canada, universities have been involved in collaborative efforts with local citizens to monitor local environmental quality. The

Watershed Watch of the University of Rhode Island, the Alabama Water Watch of Auburn University, the Rivers Project at Southern Illinois University, and the Clean Water Program at the University of Maine, among many others, all represent well-established collaborative university-community monitoring programs. Universities contribute a variety of resources to these partnerships; in some cases they go so far as to train volunteer monitors, analyze samples in the lab and interpret and report on their findings. In others, university faculty serve as expert advisors and facilitators and encourage their students to participate as monitors or as trainers. In some universities, free space, internet accounts and access to scholarly funding have jump-started volunteer monitoring groups which later became more independent of university support.

Within the array of volunteer monitoring groups, a wide diversity of mandates exist. While Lopez and Dates (1998) note that volunteer monitoring data are used primarily for education, problem identification (i.e., to act as an environmental "watchdog"), and to provide background information to assist in local decision making, there are many other agendas. A number of water quality monitoring groups have engaged in specific tasks such as monitoring for the purposes of habitat remediation and changes to government environmental protection, regulation and policy (Pinho 2000, Griffin 1999, Sinclair and Diduck 2001), and some have even launched legal suits as a result of their findings (Sharpe and others 2000).

The mandate of any given group is central to its monitoring efforts, as the intended use of monitoring data has a significant impact on the monitoring group's organization, the roles of volunteers and the monitoring activities themselves (Lopez and Dates 1998). For example, training methods and data collection may vary from non-existent to very rigorous, depending on whether the data are to be used exclusively for educational purposes, to influence policy decisions, or to provide a basis for legal action. Similarly, variables chosen for measurement may be used because they illustrate principles of water chemistry or ecology or because the variables are referenced in government regulations or agreements with local polluters. To use an example from CEW's experiences, CEW-sponsored citizen monitoring of water chemistry in the harbor of Collingwood, Ontario was initiated following the cessation of Ontario Ministry of the Environment water quality monitoring of the harbor in 1994. At that time, the harbor had been de-listed as an Area of Concern under the Canada-US Great Lakes Water Quality Agreement.

Unwilling to abandon efforts to improve the water quality of the harbor, the local environmental group,

Environment Network, monitored the harbor waters, and revealed high ammonia and abnormal pH levels. This focused attention on the continuing need for local stewardship of the harbor, and ultimately, Environment Network's findings resulted in new partnerships between citizens and water resource managers and policies to increase testing and strive to improve the water quality of the Collingwood Harbor.

Similarly, CEW was also instrumental in the volunteer monitoring at Red Hill Creek near Hamilton that led to successful prosecution of the City of Hamilton for their old leaking landfill site (Sharpe and others 2000). In this case, after initial monitoring revealed problems in the creek, members of the group Watershed Action Towards Environmental Responsibility took the City to court, where they were fined \$300,000. The City now plans to spend millions to remedy pollution at the site. There is a wide array of successful volunteer monitoring achievements, the scope of which is beyond this summary, but many further examples may be found in the USEPA's Proceedings of the 6th National Volunteer Monitoring Conference (USEPA 2000).

Despite these numerous successes, most volunteer groups have little funding and operate mainly on the motivation of a handful of individuals. In the United States, community monitors can receive nonmonetary support from the River Watch Network (RWN), a nonprofit organization that helps to establish and train citizens in water quality monitoring techniques. Similarly, USEPA provides a range of support for volunteer monitoring groups, as noted above. Yet, despite these types of assistance, it often remains difficult for small volunteer groups to maintain programs without external funding.

In Ontario specifically, the vacuum left by the provincial government's reduction in monitoring (Molot and others 2001) further stimulated the establishment of citizen-based monitoring efforts. Expensive cost-recovery charges for raw government data provided an additional incentive for citizen groups to generate their own data sets. Finally, in April of 2001 and April 1998, respectively, the popular *Pollution Watch* (Environmental Defence Canada 2002) and *Scorecard* (Environmental Defense Fund 2002) websites were launched. These resources, which display pollution sources in each postal code area across the majority of North America, not only encourage citizen environmental stewardship, but also promote the internet as a tool for volunteer environmental stewardship efforts.

The further proliferation of volunteer monitoring groups and the decisions they make about their activities will play an important role in influencing the future

of environmental protection, stewardship and rehabilitation in Ontario, Canada and North America. Choices about the variables to be monitored and the relationship with experts in academia and government shape the group itself as well as its impact on wider society. The case study of one Canadian university-citizen environmental monitoring group, Citizens' Environment Watch, shows how the choice of variables monitored, dissemination of results and the relationships with academia and with different levels of government all temper the impact of the volunteer monitoring exercise on the wider society.

Citizens' Environment Watch: Formation and Mandate

Citizens' Environment Watch—a Toronto-based grassroots nonprofit organization dedicated to environmental education and monitoring across Ontario, was formed in 1996 following severe cutbacks to the Ministry of Environment and Energy between 1995 and 1998. In the Great Lakes region, the majority of the surface water monitoring stations were eliminated and regular monitoring ceased altogether for lakes north of Barrie, Ontario (OPSEU 1997). Moreover, after the monitoring cutbacks, raw Ministry of Environment surface water monitoring data were available only for a fee. The experience of local restoration initiatives, such as the Task Force to Bring Back the Don River, the Don Watershed Regeneration Council and Save the Rouge, made it increasingly evident that citizens (and especially youth) were eager to learn about and to participate in restoring local ecosystems, rivers, streams and lakes. While creation of CEW was never intended to replace the sophisticated, widespread water quality testing previously carried out by government, its establishment was a response to these concerns.

Through the initial efforts of three university professors (Ursula Franklin and Beth Savan at the University of Toronto and Ian Brindle at Brock University), a series of interested parties came together to develop a plan for a monitoring organization. These people included a group of undergraduate students from the University of Toronto's Innis College Environmental Studies Program and an advisory committee of concerned citizens, academics and environmental group representatives. Innis College, at the University of Toronto, generously provided a base for the organization, providing free space, low cost office services, and a place where undergraduate and graduate students can participate easily in the work of the group. CEW's original mission was to safeguard and enhance Ontario's natural communities by helping citizens estab-

lish and apply the connections among science, policy, and action to improve environmental conditions. The goal was to be implemented by actively involving school and community groups in monitoring key environmental variables in the air, water and soil. Through doing so, CEW aimed not only to produce an accessible province-wide database of environmental monitoring information, but to offer relevant and engaging science learning to schools, youth associations, community groups and individuals across Ontario. By providing hands-on education and environmental monitoring resources, CEW intended to promote the role of young people as environmental stewards, which would, in turn, help to create a cohort of enthusiastic environmental investigators. CEW still maintains the long-term goal of developing a broad-based environmental monitoring network for the province of Ontario that will enable citizens and youth to collect meaningful data and then to effectively advocate for improvement in their local environmental quality.

Lessons Learned: Sample Size and Data Accuracy

Between 1996 and 2001, CEW monitored water chemistry of lakes and streams using pH, temperature, turbidity, ammonia and phosphate levels. These variables were selected because they were inexpensive, simple, safe and at the same time could be compared with historic government data. Ian Brindle and his students at Brock University developed simple measurement techniques that were written up in a set of illustrated instructions.

While all citizens groups were encouraged to do monitoring, CEW specifically targeted middle and high school students (ages 12–19) and intentionally developed the program to meet curriculum guidelines, therefore encouraging teachers (as well as their students) to get involved. Groups were provided with monitoring equipment and a creatively written field guide. Teachers also received related curriculum packages. Activity binders went out to all participants, explaining likely sources of problems revealed by each parameter monitored and outlining how to take action on any signs of environmental degradation.

During the 5 years from 1997 to 2001, an average of 20 groups per year participated in the CEW monitoring program. Each group comprised between 5 and 40 individuals, and about half the groups were school-based, while the other half were community organizations. Roughly half of the groups continued monitoring in subsequent years; attrition was largely related to teacher rotation or change in personnel of the execu-

tive of community groups to new individuals with less interest in environmental monitoring.

In 1997, when CEW analyzed the first data sets, it became clear that data quality varied; overall, about 40% of the initial samples, many of which had been collected from younger students, failed quality control checks carried out by CEW staff (Bialowas 2001). In response to these findings, CEW staff worked with scientific advisors to institute extensive quality assurance and quality control measures, including strict protocols for reagent preparation and distribution as well as procedures for blank and standard sample testing as a part of the monitoring routine (Gaweda 2002). A central debate for CEW is the question of whether it is more important to educate and empower, or to collect scientifically valid data. Most citizens monitoring groups opt to provide a warning of problematic water quality rather than a rigorous and exact indication of precise water chemistry measures. CEW's approach is outlined below.

Choice of Monitoring Variables

CEW originally selected chemical variables to provide an ongoing record of water quality at "orphan sites," which were no longer monitored by the provincial government but had many years of previous government water chemistry monitoring records. Furthermore, chemical parameters allowed citizens and youth to participate in and develop confidence measuring some of the underlying determinants of water quality, but the cost of kit preparation and distribution and the need for consistent quality assurance and quality control measures (described above) made these procedures expensive and labor-intensive. As a result, CEW decided to switch from using chemical parameters to ecosystem health indicators (benthic invertebrates, lichen and *Escherichia coli*).

An increasing body of research on biological indicators (Karr 1999) and on general ecological integrity (Pimental and others 2000) shows that bioindicators are effective monitors of ecosystem health (Fore and others 2001). Rather than giving momentary "snapshots" of water quality, as chemical measures do, biological indicators provide a cumulative assessment of overall environmental quality based on the diversity, abundance, trophic relationships and other attributes of particular groups of organisms. Biological indicators give a strong measure of the general ecological hospitality of the site—its suitability for various forms of animal life—integrating the specific variables measured by water chemistry into a single robust parameter. In addition, the Canadian government, through

the Ecological Monitoring and Assessment Network (EMAN), and local watershed conservation authorities, particularly the Toronto Region Conservation Authority (TRCA), were working with university scientists, consultants and others to develop rigorous protocols for collecting benthic invertebrates. A peer-reviewed protocol for lichens as a biological indicator of air was also developed. This protocol was created by Tom Hutchinson of Trent University, in collaboration with EMAN, who were eager to work with CEW volunteers to test these new techniques. Rigorous quality assessment and quality control routines have been established and tested to ensure the data's reliability. Those working on these new protocols were eager for partnerships with community groups to apply this work at sites in Ontario. While benthic indicator data cannot be directly compared with the water quality variables measured previously by CEW and by the provincial government, there are clear links between benthic species abundance and chemical characteristics of their habitat, such as oxygen concentration and temperature. Moreover, the use of biological indicators by volunteer monitors makes it very clear that enforcement of regulated water chemistry standards and guidelines is the responsibility of government. Finally, the current partnership among CEW, EMAN and local Conservation Authorities is promoting a number of new community-based monitoring groups, using similar biological indicators across the country.

The nature of the environmental education embedded in the monitoring activity changes with the variables measured. Chemical variables teach about water chemistry and the source and transformation experienced by pollutants that contribute to chemical variable values; biological indicators teach about the nature and value of biodiversity and ecosystem structure and give general measures of the impact of important non-point source pollutants, but give less direct insight into point sources of environmental contamination. Monitoring through the use of biological indicators provides citizens with a relatively simple yet reliable tool for assessing river and lake health, or ecological integrity (Karr 1998, Karr and Chu 2000). Furthermore, when properly trained, volunteers can collect reliable data and make stream assessments comparable to those made by professionals (Fore and others 2001). Although the proposed inclusion of *Escherichia coli* assays does provide a link with a government standard for surface water contamination, biological indicators of water and air quality are not referenced in the guidelines and standards regulating environmental quality, while chemical parameters can be directly compared with Canadian standards for surface water quality. As a

result, the move towards biological indicators brings with it a clarified role for citizen monitoring groups; changes in abundance of the indicators cannot themselves provide grounds for litigation in Canada, but they can form part of a rigorous education program, and they do sound a clear warning of upstream or upwind problems when abundance or diversity declines. This role is entirely consistent with the support provided by CEW for the monitoring which led to successful interventions in Collingwood and Hamilton carried out by local citizens groups (and described above). In effect, while giving up a more direct indicator of upstream point source pollution, CEW has helped to establish a broader and deeper understanding of ecosystem health, along with access to a growing network of similar groups monitoring biological indicators.

The movement towards biological indicators entrenches CEW's role as an educational and "watchdog" group, which becomes involved in follow-up of poor environmental quality primarily by enlisting the support of partners or agencies. CEW has collectively chosen this "red flag" role as the one that most effectively combines education, citizen empowerment and the production of useful data, while insisting on government's continuing responsibility for investigation and enforcement when environmental quality problems are detected. CEW's linkages to both the university community and government groups (such as EMAN) allowed it to make the transition rapidly, and to maintain scientific rigor, which, in turn, enhanced the strength of each of those networks.

Sharing Our Findings

In Canada there is little government support for volunteer monitors, nor is there a network linking monitors, such as the River Network in the northeastern USA. While efforts are underway by EMAN to compile a directory of monitoring groups and to help these groups communicate with each other, CEW is contributing by working with faculty and staff at York University's Map Reflections under the Sustainable Toronto project to set up a GIS-based website on which volunteer monitors may display their findings. (Map Reflections is based at *York University Centre for Applied Sustainability* as part of a larger project, *Sustainable Toronto*, funded by the Social Sciences and Humanities Research Council of Canada. The aim of the Map Reflections partnership is to establish a web-based, environmental monitoring platform providing for data collection, storage, sharing and interpretation linkages

between monitoring groups.) As a result, current CEW monitoring results are freely available on the web.

Relationship with the University

While CEW has established partnerships with many organizations to promote volunteer monitoring (see Appendix 1), the relationship with the University of Toronto is most central to our operations. CEW began as a faculty research project, staffed by undergraduates in various government subsidized job-training and volunteer positions. It has progressed to become a more stable and professional group with three well-trained full time staff supported by long-term funding (see Appendix 2). In 2002, CEW established itself as an Environmental Not For Profit organization, with separate financial, fundraising and human resources administration from the University. Innis College continues to give critical support to CEW: the College provides space for CEW and charges a modest amount for internet use and accounts and use of photocopy, mail and phone services. More importantly, CEW gains access to both undergraduate and graduate students through the Work Study system, whereby students are paid by the University and the province to work on projects related to their studies. Under this program, CEW hires (at no cost) at least six part-time University of Toronto students each year to facilitate data analysis, research and community outreach needs, and provides them with valuable work experience. Students in placement courses have also worked at CEW, and most recently, a large grant devoted to linking the University with the community has supported graduate students working part-time at CEW, which has encouraged the production of high quality reports and academic publications. In addition, Environmental Studies classes at the University of Toronto have been assigned projects related to CEW's mission, expert advisors have come forward to serve on CEW's board of directors and advisory committee, and meeting premises have been provided free of charge. In the past, the University of Toronto supported CEW in other ways as well, by providing training classes, lab analysis, and preparation of test kits.

Discussion and Conclusions

Despite the challenges of quality control, funding, government cutbacks, curriculum changes, and staff turnover, CEW is well on its way to achieving its long-term goal of establishing a Web-based monitoring network together with other partners in the educational, grassroots, scientific and academic communities. The current stable funding base, networks and community

support that CEW has garnered over the past 5 years have allowed it to flourish as a water and air-monitoring organization, and it has achieved several important successes since its creation. Despite many changes, effective, inexpensive air and water monitoring protocols using lichens, benthic invertebrates and *E. coli* that have associated QA/QC procedures have now been established and are being employed by school and community groups. CEW has established a large participant base, working with over 65 community groups and schools (Hunsberger 2002), to regularly collect monitoring data that identify potential environmental concerns and act as a baseline for future scientific assessment, has collaborated with the Ontario Science Centre to film youth for a millennium exhibition, and has worked with numerous other partners on various other outreach efforts. CEW's staff have developed a web site that makes environmental monitoring information easily accessible to the public (www.utoronto.ca/envstudy/cew/cew.htm). Work is near completion on an interactive web-based GIS mapping tool, which will provide citizens of all ages with the capacity to enter, store, retrieve and manipulate a province-wide database of monitoring data and resources. In this way, citizens and youth from communities and high schools across the province will have access to one another's site-specific data and will learn about environmental issues, monitoring parameters and protocols.

Several conclusions can be drawn from CEW's experience. The development of clear, achievable educational and stewardship goals is critical; monitoring protocols must be carefully tailored to meet these goals. Monitoring methods that allow lay citizens and youth to produce reliable data, while harnessing and enhancing their local knowledge of possible causes of environmental quality problems, are often ideal. At CEW, this has meant a move from analysis of chemical parameters to biological indicators, which give integrative and cumulative measures of environmental quality rather than the more reductionist, technical approach required by chemical testing of water quality. Using benthic invertebrates and lichens to gauge the ecological hospitality of a particular habitat can bring credibility and confidence to the citizens and youth doing the monitoring while leaving government firmly in charge of investigations and enforcement of polluters. Every volunteer monitoring group will have to make its own choices, taking into account their own needs and limits, but the increasing acceptance by government of biological indicators is a trend that should encourage more widespread participation in community monitoring of environmental quality. Moreover, quality assurance and quality control techniques can confer credibility on the

resulting data, so that they can be used to encourage further research and clean-up efforts when unusually low diversity, abundance, or other local anomalies are noted.

It is clear that staff resources, stable funding and a wide range of partnerships are critical for the delivery of long-term monitoring programs. A network of eager volunteers depends on human, financial and technical support and the inspiration and encouragement provided by meeting other citizen monitors and learning about local successes in following up on results that cause concern. These resources are ideally provided independently of industry and even government, to provide the most credibility and authority and to enable support for the follow-up efforts of local groups through advocacy, legal remedies or local clean-up and rehabilitation initiatives. While funding for local environmental monitoring and education initiatives can be obtained, the difficulties of maintaining an integrated network linking local groups and fostering communications, mutual learning and encouragement remains a very difficult hurdle. Much of this latter work is carried out by the Environmental Protection Agency in the USA; EMAN in Environment Canada and Conservation Authorities are beginning to take an interest in establishing a Canadian network of volunteer monitors.

Private support for local monitoring endeavors and government provision of conferences, general monitoring education, directories and manuals may be the most pragmatic way to ensure continuation of meaningful citizen-based monitoring. University involvement, as demonstrated by the CEW case, can also assist with all of these challenges: by supporting development of monitoring protocols, lab analysis, quality assurance and quality control procedures, training sessions, data analysis and presentation; by providing space, leadership, student support and grant administration services to the group and by conferring the credibility and infrastructure to help establish enduring and diverse partnerships with government, nongovernmental organizations, and scientific bodies. There is a risk that association with university experts can undermine citizen confidence in their own ability as lay people to produce credible results. Moreover, the academic focus on peer-reviewed publications might influence the goals and focus of the monitoring work developed at the grassroots level. Some degree of monitoring group autonomy is critical, therefore, to ensure independence, continuity and community connections. With these important caveats, community-based research linking dedicated university researchers with community activists can provide a strong model for the estab-

lishment and maintenance of community monitoring undertakings.

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Appendix 1: Partnerships

CEW is working with the federal government (EMAN), the Toronto Regional Conservation Authority (TRCA) and Dr. Tom Hutchinson of Trent University to develop the CEW lichen and benthic monitoring protocols. Over the years, CEW has also partnered with Brock University, York University's Centre for Applied Sustainability, Learning for a Sustainable Future, the Toronto District School Board, Parents Environment Network, the City of Toronto, Youth Challenge International, the Scarborough Board of Education, Frog-Watch, the Festive Earth Society and the Ontario Science Centre on a variety of workshops, displays, activities and other outreach projects. Many of these partnerships have been facilitated by academic connections to the partner agencies.

Appendix 2: Financial Supporters

To date, CEW has received financial grants and in-kind support from a range of institutions including the Social Sciences and Humanities Research Council (SSHRC), University of Toronto, Natural Sciences and Engineering Research Council, the Salamander Foundation, TransCanada Pipeline, Laidlaw Foundation, Peacock Foundation, Toronto Community Foundation, Human Resources Development Canada, EMAN, Canadian Council for Human Resources in the Environmental Industry (CCHREI), Canada Trust Friends of the Environment Fund, Great Lakes Aquatic Habitat Network and Fund, Ontario Power Generation, Three Guineas Foundation and Mountain Equipment Co-Op.

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