ON THE EVOLUTION OF THE GREAT LAKES WATER QUALITY AGREEMENT

ON THE EVOLUTION OF THE GREAT LAKES WATER QUALITY AGREEMENT:
FROM PATHOLOGICAL MANAGEMENT TO ADAPTIVE GOVERNANCE?
SKETCHES OF LEARNING FROM EXPERIENCE

by

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A Thesis

Submitted to the School of Graduate Studies

in Partial Fulfilment of the Requirements

for the Degree

Doctor of Philosophy

McMaster University

DOCTOR OF PHILOSOPHY (2011)   McMaster University
(Civil Engineering)   Hamilton, Ontario, Canada

TITLE
  On the Evolution of the Great Lakes Water Quality Agreement:
  From Pathological Management to Adaptive Governance?
  Sketches of Learning From Experience

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NUMBER OF PAGES
  xii, 142

ABSTRACT

ON THE EVOLUTION OF THE GREAT LAKES WATER QUALITY AGREEMENT: FROM PATHOLOGICAL MANAGEMENT TO ADAPTIVE GOVERNANCE? SKETCHES OF LEARNING FROM EXPERIENCE

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McMaster University, 2011

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The increasing interest in adaptive models of governance and adaptive tools for management stems from a recognition that the traditional paradigm in natural resource management is failing to adequately maintain the resilience of social-ecological systems. A principal reason for this failure is that each problem is treated discretely by approaches that are characteristically narrow and reactive rather than comprehensive and forward-looking. This lack of sophistication means that traditional governance models are unsuitable for dealing with the inherent uncertainty characteristic of environmental problems, and for dealing with the conflicts that emanate from the social construction of those problems. The challenge presented by these uncertainties and conflicts illuminates deficiencies in how we conceptualize the dynamics of social-ecological systems and how we formulate approaches to policy and problem solving to cope effectively with those dynamics. What changes in governance could remedy these deficiencies with more effective forms of collective action that sustain and enhance social-ecological resilience?

My purpose was to pursue those changes with an examination of the human dimension of governance, with specific reference to the Great Lakes and potential features of an adaptive paradigm for the Great Lakes Water Quality Agreement. The goals of this research were to contribute knowledge and perspective on our understanding of and progress towards adaptive Great Lakes governance, and secondly, to generate pragmatic and actionable policy options for enhancing participatory processes, social learning, and leadership for adaptive Great Lakes governance. To achieve these goals, I sought the following specific objectives: (1) identify aspects of the Agreement that would compel a more rigorous and evaluative approach to policy development and implementation in the Great Lakes; (2) acquire evidence to characterize deficits in the implementation of Great Lakes policy; (3) acquire evidence to characterize pathologies in the management of the Great Lakes; (4) (i) identify, detail, and combine the principles and processes of adaptive management and decision analysis, (ii) relate these mechanisms to policy and research in the Great Lakes context, especially where such mechanisms for managing in the face of uncertainty could ameliorate implementation deficits and management pathologies; and (5) (i) acquire evidence of the strengths and limitations in the development and implementation of

Great Lakes Remedial Action Plans from people with direct experience with RAPs, (ii) identify and characterize potential reforms that could improve the design of community-based, near-shore restoration programs, and (iii) measure the desirability, feasibility, and likelihood for success of those reforms.

Language in the Purpose of the Agreement, that the federal governments are to develop programs and practices for *a better understanding* of the Great Lakes, I interpret as inviting—even demanding—the ongoing and rigorous pursuit of new knowledge and improved processes in Great Lakes governance to further place-based and regional restoration. Policy implementation deficits identified included a lack of understanding of cause and effect, inadequate communication and coordination, lack of time and resources for full implementation, and lack of agreement on objectives. Pathologies of management included a lack of responsiveness, a lack of institutional analysis and program evaluation, a resistance to new information and ideas, a lack of appropriate personalities in key roles, and multiple and incompatible programming. Policy tools for improved human-environment and science-policy linkages were examined as potential governance mechanisms to counter deficits and pathologies. Design principals of adaptive management and decision analysis were specified. These tools were placed within the policy and research context of the Great Lakes regime and linked to improved forms of accountability.

A three-round online Policy Delphi study involved several dozen experts in the development and implementation of RAPs across the Great Lakes basin within government, industry, academia, and civil society. The research collected and aggregated (1) direct knowledge of the strengths and limitations of RAPs, which lead to (2) further knowledge of what worked and what did not work in the RAP program, which in turn facilitated (3) the emergence of seven governance options to improve institutional processes in RAP programming. Importantly, the results establish that both the *structure* and *attributes* of governance were significant to RAP outcomes. Rankings of these options indicated a general consensus that the options were relatively feasible and likely to succeed as enhancements in the development and implementation of RAPs. The results indicate a need to focus significantly on the predominant tendencies and characteristic attitudes that underlie RAP processes. These findings will have broad significance for other evolving place-based nearshore restoration strategies in the Great Lakes and anywhere else such programs are initiated.

The thesis culminates with a conceptual framework for adaptive governance, problem solving, decision making, and management. The framework encompasses three domains that correspond to established levels of institutional analysis: constitutional choice (political and societal processes), collective choice (policy and decision processes), and operational choice (resource use and management processes). Flows of information between domains can be facilitated or restricted depending on the rules and conventions of the institutional design. Tradi-

tional governance characteristically permits only a linear and downward flow of information that negates the possibility for double-loop learning by disallowing required feedbacks. Adaptive governance regimes intentionally encourage a return or upward (and outward) flow of information and promotes learning. The three domains in the framework are nested to indicate that the 'problem domain' is the entire social system, that problems of environmental governance cannot be restricted to subsets of issues, and that adaptive problem solving is multi-scalar. The framework explicitly links processes across domains and is adaptive because it bridges boundaries that traditionally separate society from policy decisions and isolate policy decisions from management activity. The Discussion underscores that learning is a key function of adaptive governance, and that it is operationalized through social capital, networks, leadership, and trust. The thesis recommends that the federal governments issue a reference to the International Joint Commission to establish an Adaptive Governance Task Force in order to provide a strong and independent forum to engage with the conceptual framework presented in this thesis and generally to discover adequate and appropriate strategies and opportunities for adaptive Great Lakes governance.

For Simon and Avery.

And for the Salmon River and its watershed—a small parcel of which,
in Lennox & Addington County, Ontario, farmed by my family first and still,
is my favourite place in the Great Lakes basin.

ACKNOWLEDGMENTS

> Generally, by the time you are Real, most of your hair has been loved off, and your eyes drop out and you get loose in your joints and very shabby. But these things don't matter at all, because once you are Real, you can't become unreal again. It lasts for always.
>
> —Margery Williams, 1922
> *The Velveteen Rabbit*

As it turns out, doctorates don't make great hobbies, regardless of your temperament. Especially when they're written in large part at the craft table in the toy room, and dolls and dinosaurs must be cleared from the keyboard each evening. Happily, though, an excellent answer to *Why bother?* emerged that was much more revelation than motivation: that through this experience—including as it did, significantly, several iterations in organizational leadership and entrepreneurial adventure—I have become much more Real. (Which is simply to recognize that, in John Dewey's words, "the self is not something ready-made, but something in continuous formation through choice of action.") That Realness is why, despite the challenges and setbacks, my mind's journey through the ideas explored in these pages has been a privilege for which I am deeply appreciative.

My advisor, Gail Krantzberg, has my gratitude and affection in great abundance. Gail has been a friend and mentor, ever enthusiastic and encouraging. In continually pushing me to think both of scholarship and the policy context for my research, her support and expertise has defined this experience as a true education. I also have great respect and appreciation for Brian Baetz, Steve Crawford, and Velma Grover for their support and for challenging me to be clear with words and ideas; my work is better having benefited from their collective insights. Special thanks to Brian for his initial advocacy and supervision, and for helping me in the right direction.

Henry Regier once wrote of a renaissance of the earlier, deeper features of conservationism being complemented by a broadening of interdisciplinary scholarly interactions. I hope that my research furthers that awakening, in even the smallest measure, and I thank Henry for engaging me over the years in many thoughtful and boundary-crossing discussions. Ditto George Francis, Bob Gibson, and Tom Nudds. Others have reviewed parts of this thesis or otherwise engaged me in this work, most notably Jonathan Bulkley, John Gannon, Mike Jones, Tom Mac-Dougall, Scudder Mackey, Mark Sproule-Jones, Rob Stewart, and Graham Whitelaw. Research

on Chapter Four was supported by the International Joint Commission. Karen Szala-Meneok and Johnny Saldaña were terrific in helping to improve the study design in Chapter Five. The Delphi study is the heart of the thesis for me, and it would not have been possible without the contribution of dozens of RAP veterans in providing their knowledge and experience to this research. For that collective effort, I am very grateful.

I am also grateful to Lee Botts and Paul Muldoon for their effort to research and write *Evolution of the Great Lakes Water Quality Agreement*—perhaps, said one otherwise positive review, "the driest book ever written on the world's wettest topic." Their chronicle is a tremendous resource for those who are curious about the past and care deeply about the future of the Great Lakes, and I doubt that there's a copy anywhere more dog-eared than mine. I was employed at McMaster during the first three years of this degree and took advantage of a generous staff tuition bursary. I appreciated the foresight of the University in providing such a benefit, and the support of Michelle Benjamin, my manager at the time. Thanks also to Deborah Smaluck in the School of Engineering Practice for helping to facilitate my research during the time I spent on campus.

The scope and depth of my research was informed significantly by professional roles and relationships off campus, both in business and non-profit leadership. I have learned a great deal from a great many, but a few people stand out. It is not possible to underestimate the importance of my friendship with Corrie Schneider, nor the influence of her knowledge and experience on my understanding of 'the firm'. Friends and mentors Sonia Hawrylyshyn, Ken Roberts, and Anne Varangu each contributed a generous amount of time and wisdom to my appreciation of how to 'make friends and influence people'. And as always, I am very grateful for my parents, George and Dovie, as each of them in their own way is to blame for how I turned out.

My deepest gratitude is for my wife, Tracy, for her acceptance, love, and support. My attention to this so-called 'part-time' endeavour put a sustained strain on my family, and she was vital in both shouldering burdens and sharing beatitudes. This thesis is dedicated to our son and daughter, Simon and Avery, for the extraordinary joy that they have brought into our lives. As Gordon Young asked in *National Geographic* when I was just a child myself, "what more precious legacy could we leave our children than five shining inland seas?"

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The man who has the time, the discrimination, and the sagacity to collect and comprehend the principal facts and the man who must act upon them must draw near to one another and feel they are engaged in a common enterprise.

—U.S. President Woodrow Wilson, 1910
to the American Political Science Association

Organizations, which deal with the collective efforts of men, are devoted to the processing of information and the generation of knowledge. Their ability to test the environment so as to correct error and reinforce truth makes them effective. Inability to learn is fatal. Yet learning is more difficult because so many men must do it together.

— Jeffrey Pressman & Aaron Wildavsky, 1973
Implementation

So, what if... we assumed that learning is, in its essence, a fundamentally social phenomenon, reflecting our own deeply social nature as human beings capable of knowing? What kind of understanding would such a perspective yield on how learning takes place and on what is required to support it?

—Etienne Wenger, 1998
Communities of Practice

INTRODUCTION

The people of both countries possess, in the splendid immensity
of the series of waterways through which so much of their com-
mon boundary passes, a heritage of inestimable value.

The reference [from the Canadian and U.S. governments to the
International Joint Commission in 1912 to examine the extent,
causes, and localities of polluted Great Lakes boundary waters]
has imposed upon the commission grave responsibilities. From
the language of the submission... it is evident that the object
which the two Governments had in view in making the refer-
ence was to see that their reciprocal obligations with respect to
the pollution of those waters should be fulfilled.

—International Joint Commission, 1918
Final Report in the Matter of the Reference by the United States and
the Dominion of Canada Relative to the Pollution of Boundary Waters

The measure of an idea should extend beyond its appeal. The idea that the governance and
management of natural resources should be *adaptive*, for example, has become increasingly ap-
pealing. This growing popularity for an adaptive model of governance and adaptive tools for
management stems from a recognition that the traditional paradigm in natural resource man-
agement is failing to adequately maintain the resilience of social-ecological systems (Gunderson
et al., 1995; Dietz et al., 2003). A principal reason for this failure is that those traditions continue
to treat each natural resource problem discretely, despite that almost all of the ways in which
human systems engage with environmental systems produce "coincident or parallel effects"
(Margalef, 1975; also Berkes et al., 2003; Folke et al., 2005). The result is governance and man-
agement that is characteristically narrow and reactive rather than comprehensive and forward-
looking (Carter, 2001). This lack of sophistication means that traditional approaches are unsuit-
able for dealing with the inherent uncertainty characteristic of environmental problems, and for
dealing with the conflicts that emanate from the social construction of those problems (Miller,
1999; Best, 2008). Therefore, the challenge of 'solving' complex or "wicked" (Rittel and Webber,
1973) problems such as transboundary pollution illuminates deficiencies in how we conceptual-
ize the dynamics of social-ecological systems, and how we formulate approaches to policy and

problem solving to cope effectively with those dynamics. The measure of adaptive governance will therefore be our capacity to remedy these deficiencies with more effective forms of collective action to sustain and enhance social-ecological resilience.

My purpose was to address these deficiencies with a framework for reconceptualizing and reformulating governance to be effectively adaptive, with specific reference to the Great Lakes and potential features of an adaptive paradigm for the evolving Great Lakes Water Quality Agreement. This introduction briefly describes elements of adaptive governance and the Agreement central to this purpose, highlights deficiencies in current Great Lakes governance, and outlines the goals and objectives that I set in order to investigate the characteristics and elements of a substantial and adaptive renewal of the Agreement.

Governance

Water governance is broadly considered to be the institutional design and decision making processes through which water is consumed and managed (WRI 2003; de Loë and Kreutzwiser, 2007). These processes represent the "complex art of steering multiple agencies, institutions, and systems which are both operationally autonomous from one another and structurally coupled through various forms of reciprocal interdependence" (Jessop, 2005). Such governance is "good" when environmental problem solving and decision making is transparent, fully participatory, linked with ethical concerns and accountability measures, and when decisions are integrated with socioeconomic developments (WRI, 2003; also Rogers and Hall, 2003; WWAP, 2003). (It follows that governance is 'not good' when problem solving and decision making processes are exclusionary and concealed from public view, when actions are taken without obligation to consult or report, and when little or no consideration is given to coincidental and unforeseen circumstances that could result from the outcomes of policy with a narrow scope.)

Governance that is adaptive "involves the evolution of new governance institutions capable of generating long-term, sustainable policy responses to wicked problems through coordinated efforts involving previously independent systems of users, knowledge, authorities, and organized interests" (Scholz and Stiftel, 2005). The idea of adaptive governance both requires and encourages social sources of resilience such as trust and a capacity for collaboration, and recognizes that delineations between social and ecological systems are useful but always arbitrary (Folke et al., 2005). Adaptive governance connects stakeholders in ways that builds acceptance and legitimacy for learning processes designed to improve human understanding and cope with uncertainty (Folke et al., 2005). So-called "new" governance mechanisms are considered superior in that they (Lemos and Agrawal, 2006):

- integrate scientific, technological, and lay knowledge and quickly relay information,

- provide sufficient redundancy and flexibility in functional performance,

- gain the involvement of multiple actors,

- recognize that the relationship between institutional regimes and nonstate actors is fundamental to address economic and environmental changes,

- identify modes of cooperation that go beyond legal arrangements,

- work across scales to develop cooperation and synergy to solve common problems, and

- promote social learning and compromise seeking.

These characteristics of new governance correspond with the growing relationship between the "new" ecology and the social sciences based on situated analyses of 'people in places', a growing understanding of environment as both the product of and the setting for human interactions, and an appreciation that complexity and uncertainty in social-ecological systems dramatically limits our management and control in these environments (Scoones, 1999).

Great Lakes Water Quality Agreement

The long history of innovation in Great Lakes water governance includes the 1909 Boundary Waters Treaty (BWT) that established the International Joint Commission (IJC) (Valiante et al., 1997; Botts and Muldoon, 2005). The IJC was granted quasi-judicial power to apply governing principles for water use and arbitral power to resolve boundary water disputes. On occasion the two federal governments have referred specific issues to the IJC to investigate and provide them with non-binding recommendations. Since 1972, the GLWQA has been a standing reference from the federal governments of Canada and the United States to the IJC.

The Agreement expanded the independent role of the IJC to oversee implementation processes, and to assess the effectiveness of federal and other programs and report on progress towards meeting the Agreement's objectives (Botts and Muldoon, 2005). For much of its history, the IJC "has been justly celebrated as a highly effective mechanism for regulating, and if possible resolving, the transborder problems which principally involve water resources..." (Spencer, 1981). However, the amendments to the Agreement in 1987 that created the Binational Executive Committee (BEC) also led to the withdrawal of the governments from the IJC framework over time. The creation of this "unsatisfactory" parallel processes under the BEC has also failed to provide "meaningful information" through the governmental State of the Lakes Ecosystem Conference (SOLEC) (Botts and Muldoon, 2005; also Barr et al., 2010).

Indeed, the failure of traditional governance is evident in the Great Lakes, as jurisdictional, administrative, and disciplinary barriers fragment knowledge and constrain a comprehensive understanding and treatment of social-ecological dynamics and impede the development of

the intelligence system required to be adaptive (Francis and Regier, 1995; also Acheson, 2006). Such failures ultimately relate to "people issues" rather than to a lack of science knowledge or adequate technology (WWAP, 2003; also Miller, 1999). Manno and Krantzberg (2008) suggest that the nature of this failure of governance in the Great Lakes is paradoxical: as recognition for the growing complexities of problems in the Great Lakes began to form within the institutional regime following a period of "incredible energy and government commitment," the regime became "mired in controversy and inaction" under the influence of the policy challenges that emerged following revisions to the Agreement in 1987. This thesis intends to inform a reconciliation of this paradox, that an appropriate response to renew Great Lakes governance could embrace those policy challenges with initiatives that also revitalize that energy.

The decline in the effectiveness of Great Lakes governance has also been attributed, in addition to the diminished evaluative capacity of the IJC, to a lack of clarity regarding application of the ecosystem approach (Manno and Krantzberg, 2008). The ecosystem approach was a principal innovation in the 1978 amendments to the Agreement, and the 1987 revisions created the Remedial Action Plan program in targeting dozens of the most degraded local environments for community-based restoration[1]. The RAP program has been the principal program to operationalize the ecosystem approach to management in the Great Lakes. Progress since 1987 has been slow and disappointing, however (Botts and Muldoon, 2005). It is possible that the program may be terminated in future. Or it may be subsumed into a new framework for addressing chronic environmental degradation in nearshore areas despite very little systematic inspection of the social, collaborative strengths and limitations of RAP development and implementation. It is of "critical importance in the ecosystem approach... to identify and understand the critical interactions that are taking place in the system of interest" (Bulkley et al., 1989). "Reconciling the webs of functional interconnectedness among institutions with the functional webs of non-human ecosystems is a challenge for the ecosystem approach and its dimensions are but dimly perceived" (Francis, 1986).

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[1] The term *restoration* is used in Article II of the Agreement in describing, in part, what the federal governments are to accomplish through the Agreement's implementation. Clewell and Aronson (2006) state that "reasons ecosystems should be restored are numerous, disparate, generally understated, and commonly underappreciated." This is often true in the Great Lakes with respect to the diversity of world views imposing on definitions of the problems and solutions to environmental degradation. Restoration efforts in the Great Lakes also lack a clear definition of what restoration beyond the outdated objectives in the Agreement's Annexes would entail, how it might be measured, and what states of nature would be considered sufficient. Other terms commonly used in the Great Lakes context, such as *rehabilitation*, give the impression of minimal recovery. Others, such as *revitalization*, suggest a much more resilient state is the desired outcome. I use the term restoration to adhere with the language of the Agreement, but in doing so I am referring generally to the social-ecological resilience of the Great Lakes, particularly where the Purpose in Article II also requires that the restored state be *maintained*. I contend that ongoing, adaptive processes therefore, rather than a reliance on endpoints alone, are needed to gauge and maintain restored states of nature.

The urgency for developing and using adaptive governance mechanisms that improve social-ecological outcomes in Great Lakes restoration is underscored, however, by a "widespread agreement that the Great Lakes presently are exhibiting symptoms of extreme stress from a combination of sources that include toxic contaminants, invasive species... [and that the] failure to understand the ecosystem-level disruptions caused by the combination of multiple stresses have led to the false assumption that the Great Lakes ecosystem is healthy and resilient (Bails et al., 2005). Nearly a century has passed since it was observed that Great Lakes restoration imposes "grave responsibilities" on authoritative agencies such as the IJC, and "reciprocal obligations" on the governments—and never has the seriousness of these charges been as great as it is at present.

Sketches of Learning From Experience

The growing interest in adaptive forms of governance and management in natural resources and other disciplines represents the kind of conceptual development that is common when stimulating ideas move across intellectual boundaries (Crawford et al., 2010). Such movement can combine ideas in powerful new ways to think about old problems. The idea of learning is a key element of adaptive governance (Folke et al., 2005; Lemos and Agrawal, 2006) and adaptive management (Crawford et al., 2005). Learning is considered in various parts of the thesis on two levels: in the sense of social learning (Lee, 1993) as the broad cultural transmission and accumulation of knowledge (Berkes, 1999), particularly with respect to inclusive community participation in governance (e.g., the RAP program; Hartig, 1997); and secondly, in the sense that management actions involve tools for problem-solving and decision-making to obtain new knowledge with which to better understand the world (i.e., learn), and 'adapt' by making better decisions about future management plans because that better understanding has reduced our uncertainty about how the world works (e.g., Murray and Marmorek, 2004; Williams et al., 2009). Both of these modes of learning share a necessary attention to the social processes and characteristics required to legitimize and sustain them. By emphasizing the procedural and cultural aspects of learning as equally important, I link together the three quotations on the page preceding this Introduction: adaptive governance is a modern "common enterprise" and our task is to discover and support ways to learn together across those boundaries that have traditionally fragmented science and policy, people and decisions.

The purpose of the federal governments, as stated in the Agreement, is "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem." But to achieve this purpose, they are "to make a maximum effort to develop *programs, practices* and technology *necessary for a better understanding* of the Great Lakes Basin Ecosystem" [my emphasis]. Central to that understanding will be insights about factors that

have limited restoration of the Great Lakes. A better understanding requires that those factors be characterized; more effective restoration efforts require that those factors mitigated. This thesis investigated the human dimensions of the problems hindering more impactful Great Lakes programming; it is structured around three basic elements of the systems engineering approach consisting of problem definition, solution proposal, and solution evaluation. Chapter One begins the process of defining the this problem by promoting that better understanding through an investigation of the gaps between the goals and accomplishments of the Great Lakes institutional regime, principally regarding management interventions taken under the Great Lakes Water Quality Agreement. Specifically, I used published criteria with which to structure evidence of policy implementation deficits and management pathologies in the Great Lakes in Chapters Two and Three, respectfully, to characterize and illustrate these two human dimensions of the failure of Great Lakes governance. These deficits will continue to frustrate the restoration of Great Lakes resilience unless significant advances are made to design governance processes that accommodate the complexity of linked social and ecological systems. Institutional regimes that are narrow and reactive, however, fail to make appropriate adjustments to new knowledge and opportunities due to inflexibility and inattentiveness—traits that are pathological.

The long history of abuse and neglect in the Great Lakes is also one of searching for the modes of problem solving and human organization required to sufficiently redress that degradation. Our institutions must continue to evolve and keep pace with our understanding. In Chapter Four I documented innovations in decision making that are proposed to facilitate adaptive problem solving in Great Lakes governance. Finally, I conducted a structured and iterative collection and reconsideration of direct expert knowledge of the strengths and limitations of RAPs among a diversity of RAP practitioners in Chapter Five based on characteristics of adaptive governance. That knowledge was related to both the procedural structure and characteristic attributes of RAP governance, and used to design and test seven policy options for consideration in the reform of Great Lakes governance.

A sketch is a delineation of something, giving its outline or prominent features (OED, 2010). I refer to the chapters in this thesis as sketches because they delineate both deficiencies in the traditional natural resource management paradigm and prominent features of adaptive governance and policy mechanisms that might be incorporated into future Great Lakes governance models to mitigate those deficiencies. Taken together, these sketches provide a broad foundation for appreciating the human dimensions of the lack of progress in restoring the Great Lakes, and contribute to a conceptual framework for reconsidering the scope, development, implementation, and evaluation of the Agreement—a framework for reimagining the institutional approach to Great Lakes restoration.

Research Goals

The primary goal of this research was to contribute knowledge and perspective to our understanding of the Great Lakes "organizational ecosystem" (Francis, 1987) by identifying and examining factors that have facilitated or limited restoration programs under the Great Lakes Water Quality Agreement. Secondarily, the research was intended to develop pragmatic policy options and recommendations from the evidence acquired regarding participatory processes and institutional learning for adaptive Great Lakes governance, especially with respect to the ongoing renewal of the Agreement. To achieve those primary and secondary goals, I sought the following specific objectives:

1. Identify aspects of the Agreement that would compel a more rigorous and evaluative approach to policy development and implementation in the Great Lakes. [Chapter One]

2. Acquire evidence from primary and secondary literature to describe and characterize deficits in the implementation of Great Lakes policy. [Chapter Two]

3. Acquire evidence from primary and secondary literature to describe and characterize pathologies in the management of the Great Lakes. [Chapter Three]

4. Identify and describe principles and processes of adaptive management and decision analysis; and relate these policy mechanisms for managing in the face of uncertainty to both a description of decision making and to the potential for new approaches to governance that could reduce implementation deficits and management pathologies in the Great Lakes. [Chapter Four]

5. Acquire evidence of the strengths and limitations in the development and implementation of Remedial Action Plans under the Agreement using a survey of people with direct experience in those activities; identify and characterize potential program reforms to improve the design of placed-based, nearshore restoration commitments in the Agreement; and measure the desirability, feasibility, and likelihood for success of those reforms. [Chapter Five]

Contribution to Scholarship

Some of the chapters in this thesis have been published or are being peer reviewed for publication with Gail Krantzberg listed as my co-author. The purpose of this section is to briefly preface those chapters with a clarification of my contribution to those manuscripts (and in doing so, explain their inclusion in the main body of the thesis).

I identified the phrase "better understanding" in the purpose of the Agreement as being an invitation to foster more effective science-policy links in Great Lakes programs and more thorough and evaluative policy mechanisms (as discussed in Chapter One). I also originated the idea to appraise policy and management under the Agreement, discovered the published criteria of implementation deficits and management pathologies that were used in the analyses

of Chapters Two and Three, and collected the evidence for these phenomena from primary and secondary sources. I examined several potential cases for their suitability to fulfil the general objective of Chapter Five (i.e., to identify and characterize potential program reforms to improve the design of restoration commitments in the Agreement) before determining that an examination of RAPs would be ideal for my purpose. Gail Krantzberg critiqued my ideas, lines of argument, and the evidence I gathered for each of these chapters. She provided suggestions of literature and other resources I could consult, including the use of the Delphi technique. Although in peer-reviewing all of my writing she ensured that her expertise was brought to bear on the final product, I was, in every sense, the principal originator, designer, and author of all materials in this thesis.

Finally, the thesis chapters were written so as to each stand on their own. As such, there will be some written material and literature cited that is repeated once or more. The purpose of the Agreement is an example. Material has been repeated only when necessary to meet the objective of any given chapter. Each chapter has a unique listing of literature cited, and the formatting of the references has been standardized for this thesis (from the style required by the journal to which the chapter was submitted). Some chapter sections that were not named or numbered in manuscripts as they were submitted for publication have in some cases here been named or numbered for the purpose of their cohesive inclusion in the thesis.

Literature Cited

Acheson JM. 2006. Institutional failure in resource management. Annual Review of Anthropology, 35: 117-134.

Bails J, Beeton A, Bulkley J, DePhilip M, Gannon J, Murray M, Regier H, Scavia D, 2005. Prescription for Great Lakes Ecosystem Protection and Restoration: Avoiding the Tipping Point of Irreversible Changes. Wege Foundation and Joyce Foundation. Accessed 29 Jan 2011 at http://nsgl.gso.uri.edu/michu/michui05009.pdf.

Barr, J., Hall, T.J., Harris, H.J., Krantzberg, G., Sowa, S. 2010. Review Report of the SOLEC Independent Expert Panel. Presented to Environment Canada and the U.S. Environmental Protection Agency. Accessed 30 Nov 2010 at http://msep.eng.mcmaster.ca/epp/publications.html.

Becker CD, Ostrom E. 1995. Human ecology and resource sustainability: the importance of institutional diversity. Annual Review of Ecology and Systematics, 26: 113-33.

Berkes F. 1999. Sacred Ecology: Traditional Ecological Knowledge and Resource Management. Taylor & Francis.

Berkes F, Colding J, Folke C, editors. 2003. Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press.

Best J. 2008. Social Problems. W.W. Norton & Company.

Botts L, Muldoon P. 2005. Evolution of the Great Lakes Water Quality Agreement. Michigan State University Press.

Brandes OM. 2009. Practicing ecological governance: the case for the soft path for water. In: Making the Most of the Water We Have: The Soft Path Approach to Water Management. Brooks DB, Brandes OM, Gurman S, editors. pp. 63-73. Earthscan.

Bulkley JW, Donahue MJ, Regier HA. 1989. The Great Lakes Water Quality Agreements: how to assess progress toward a goal of ecosystem integrity. In: Post Audits of Environmental Programs and Projects. Gunnerson CG, editor. pp. 27-42. Proceedings of a session sponsored by the Environmental Impact Analysis Research Council of the American Society of Civil Engineers in conjunction with the ASCE Convention in New Orleans, Louisiana, 11 Oct 1989.

Caldwell LK. 1988. Implementing an ecological systems approach to basin-wide management. In: Perspectives on Ecosystem Management for the Great Lakes: A Reader. Caldwell LK, editor. pp. 1-29. State University of New York Press.

Carter N. 2001. The Politics of the Environment: Ideas, Activism, Policy. Cambridge University Press.

Clewell AF, Aronson J. 2006. Motivations for the restoration of ecosystems. Conservation Biology, 20: 420-428.

Crawford S, Matchett S, Reid K. 2005. Decision Analysis/Adaptive Management (DAAM) for Great Lakes Fisheries: A General Review and Proposal. Draft discussion paper presented to the International Association for Great Lakes Research Conference, Ann Arbor, MI. Accessed 15 Mar 2010 at http://www.uoguelph.ca/~scrawfor.

Crawford S, Wehkamp CA, Smith N. 2010. Translation of Indigenous/Western Science Perspectives on Adaptive Management for Environmental Assessments. Canadian Environmental Assessment Agency, Research and Development Monograph Series. Accessed 8 Jan 2011 at http://www.ceaa.gc.ca/7F3C6AF0-docs/TIWSPAMEA-eng.pdf.

de Loë R, Kreutzwiser R. 2007. Challenging the status quo: the evolution of water governance in Canada. In: Eau Canada: The Future of Canada's Water. Bakker K, editor. pp. 85-103. UBC Press.

Dietz T, Ostrom E, Stern PC. 2003. The struggle to govern the commons. Science, 302: 1907-1912.

Folke C, Hahn T, Olsson P, Norberg J. 2005. Adaptive governance of social-ecological systems. Annual Review of Environment and Resources, 30: 441-473.

Francis G. 1986. Great Lakes governance and the ecosystem approach: where next? Alternatives 13.3: 61-70.

Francis G. 1987. Toward understanding Great Lakes "organizational ecosystems". Journal of Great Lakes Research, 13: 233.

Francis GR, Regier HA. 1995. Barriers and bridges to the restoration of the Great Lakes Basin ecosystem. In: Barriers and Bridges to the Renewal of Ecosystems and Institutions. Gunderson LH, Holling CS, Light SS, editors. pp. 239-291. Columbia University Press.

Gunderson LH, Holling CS, Light SS, editors. 1995. Barriers and Bridges to the Renewal of Ecosystems and Institutions. Columbia University Press.

Hartig JH. 1997. Great Lakes remedial action plans: fostering adaptive ecosystem-based management processes. American Review of Canadian Studies, 27: 437-458.

IJC [International Joint Commission]. 1918. Final Report on Boundary Waters.

Jessop B. 2005. The governance of complexity and the complexity of governance. Department of Sociology, Lancaster University. Accessed 18 Jan 2010 at http://www.lancs.ac.uk/fass/sociology/papers/jessop-governance-of-complexity.pdf.

Lee KN. 1993. Compass and Gyroscope: Integrating Science and Politics for the Environment. Island Press.

Lemos MC, Agrawal A. 2006. Environmental governance. Annual Review of Environment and Resources, 31: 297-325.

Margalef R. 1975. Human impact on transportation and diversity in ecosystems. How far is extrapolation valid? In: Proceedings of the First International Congress of Ecology. Structure, Functioning, and Management of Ecosystems. pp. 237-241. The Hague, Sept. 8-14, 1974. Centre for Agricultural Publishing and Documentation, Wageningen, Netherlands.

Manno J, Krantzberg G. 2008. Rediscovering and revitalizing the Great Lakes governance. In: Governance for Sustainability: Issues, Challenges, Successes. Bosselmann K, Engel R, Taylor P, editors. pp. 159-170. IUCN Environmental Policy and Law Paper No. 70.

Miller A. 1999. Environmental Problem Solving: Psychosocial Barriers to Adaptive Change. Springer.

Murray C, Marmorek DR. 2004. Adaptive management: a spoonful of rigour helps the uncertainty go down. Proceedings of the 16th Annual Society for Ecological Restoration Conference, Victoria BC, Aug 24-26. Accessed 11 Mar 2010 at http://www.essa.com/publications/index.html.

OED [Oxford English Dictionary]. 2010. Oxford English Dictionary, Online edition. Oxford University Press.

Rittel HWJ, Webber MM. 1973. Dilemmas in a general theory of planning. Policy Sciences, 4: 155-169.

Rogers P, Hall AW. 2003. Effective Water Governance. Global Water Partnership, TEC Background Paper No. 7.

Scholz JT, Stiftel B. 2005. Introduction: the challenges of adaptive governance. In: Adaptive Governance and Water Conflict: New Institutions for Collaborative Planning. Scholz JT, Stiftel B, editors. pp. 1-11. Resources for the Future.

Schusler TM, Decker DJ, Pfeffer MJ. 2003. Social learning for collaborative natural resource management. Society & Natural Resources, 15: 309-26.

Scoones I. 1999. New ecology and the social sciences: what prospects for a fruitful engagement? Annual Review of Anthropology, 28: 479-507.

Spencer R. 1981. Preface. In: The International Joint Commission Seventy Years On. Spencer R, Kirton J, Nossal KR, editors. pp. vii-ix. Centre for International Studies, University of Toronto.

Susskind L. 2005. Resource planning, dispute resolution, and adaptive governance. In: Adaptive Governance and Water Conflict: New Institutions for Collaborative Planning. Scholz JT, Stiftel B, editors. pp. 141-149. Resources for the Future.

Valiante M, Muldoon P, Botts L. 1997. Ecosystem governance: lessons from the Great Lakes. In: Global Governance: Drawing Insight from Environmental Experience. Young OR, editor. pp. 197-225. MIT Press.

Williams BK, Szaro RC, and Shapiro DD. Adaptive Management: the U.S. Department of the Interior Technical Guide (Revised edition), Adaptive Management Working Group, US Department of the Interior, Washington, DC, USA. Accessed 10 January 2011 at http://www.doi.gov/initiatives/AdaptiveManagement/documents.html.

WRI [World Resources Institute]. 2003. World Resources, 2002-2004. World Resources Institute.

WWAP [World Water Assessment Programme]. 2003. Water for People, Water for Life: The United Nations World Water Development Report. UNESCO Publishing.

TOWARDS A 'BETTER UNDERSTANDING' OF THE GREAT LAKES BASIN ECOSYSTEM[2]

That the purpose of the Great Lakes Water Quality Agreement (the Agreement) is to "restore and maintain the physical, chemical, and biological integrity of the waters of the Great Lakes Basin Ecosystem" will certainly be familiar to anyone acquainted with the document. It is perhaps the most oft quoted text from the Agreement throughout the body of literature that has built up concerning it. In contrast to the ubiquitous mention of the purpose, however, is the neglect of the means by which the Agreement instructs that the purpose is, in large measure, to be met: through a "better understanding" of the Great Lakes Basin Ecosystem (the Basin). We focus here on the implications of our collective failure to emphasize this instructional phrase and suggest a critical role for a "better understanding" to be considered during the present review of the Agreement.

The phrase "better understanding"—and the spirit that it embodies—has not received adequate attention in efforts to restore and maintain the waters of the Basin. This is no trivial matter. While Great Lakes researchers have made unquestionable gains advancing our understanding of ecological form and function in the Basin, the importance of a social science for Great Lakes sustainability must be equally up to the task. The issue is that while research has improved our knowledge of individual aspects of the Basin, we continue to lack flexible institutional structures that would enable us to synthesize and learn from that research. These structures will be required so as to form coherent policy based on a systemic, "better" understanding of sustainable systems.

Botts and Muldoon (2005) have suggested that the Agreement allows for flexibility, for example, in requiring a periodic review (Article X(4)) that permits adjustments to the policy and programs under changing conditions, or where scientific research solves known or reveals new problems. While technically this is true, there is little evidence outside of, for example, Annexes 2 and 15, to suggest that in the spirit of a "better understanding" this, in fact, is the reality. The Agreement was revised in 1987 and called on the parties to meet twice yearly to coordinate their respective work plans and to evaluate programs. Consequently, the role of the International Joint Commission (IJC) was diminished. Since the establishment of the Binational Executive Committee (BEC) in 1991, there has been no evaluation by the governments of the

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[2] McLaughlin C, Krantzberg G. 2006. Toward a 'better understanding' of the Great Lakes Basin Ecosystem. Journal of Great Lakes Research, 32: 197-199.

effectiveness of BEC or the IJC and its institutions. On the question of whether this revision has been helpful or harmful there has been little if any formal inspection. Will the upcoming review of the Agreement look back at 1987 to examine the consequences of these changes for Great Lakes governance under the Agreement?

Discord over the most effective scope for the Agreement or its correct amount of inclusivity of issues has also occurred on these pages. Postulating simple cause and effect relationships will not make the actual existing problems and emerging stressors in the Basin any less complex and uncertain. While we concur with Kelso and Minns (2000) that the argument of Bowerman et al. (1999)—that chemical injury must remain the principal focus of the Agreement—is too restrictive in scope, we believe that the increasingly complex nature of the issues now demands an even further evolution of our ecosystemic response and means of institutional learning.

One of us has argued previously on these pages that the interface between science and policy is fundamental to achieving sustainability in the Basin (Krantzberg 2004). It was suggested that scientists and policymakers commonly disengage because they lack sufficient appreciation for the other's domain (i.e., "the scientific community tends to consider the 'resource' as the starting point and the policy maker considers the 'social consequences' of resource use as a starting point"). The promise of the synergistic engagement of these two realms—theory and practice, research and policy—has motivated the IJC's Science Advisory Board (SAB) to call for greater integration between science and policy. A better understanding will only come from a governance model that fosters learning.

The SAB's 1999-2001 contribution to the IJC's Priorities Report (IJC 2001) recommended that the IJC "comprehensively identify and review emerging issues". A principal objective of the SAB's emerging issues workshop in 2003 was to identify "specific initiatives that represent the most promising future opportunities for sustaining progress under the Great Lakes Water Quality Agreement" (IJC 2003). The workshop went on to conclude that the current governance structure is fundamentally unable to stop new and re-emerging stressors. The SAB has recently suggested that the Agreement should be examined for opportunities to provide "greater integration" between science and policy. It contends that there has been a tendency for science and policy to be "overcompartmentalized, with policy frequently lagging behind current scientific understanding." Further, the SAB identified the need for "greater institutional capacity" and to "reduce scientific uncertainty". We allow that the Bowerman et al. view could prove instructional, but this again underscores our point: that we must alter our governance structure to ensure that improved science does, in fact, lead to a "better understanding", because we are unable to form ecosystemic conclusions and responses given the institutional machinery currently in existence.

The traditional modus operandi in resource management has been to fine tune existing programs and policies. We assert that fundamental changes in institutional sensibilities are required for sustainability, where sustainability is viewed not necessarily as an identifiable end point but as a process of continual re-examination and redefinition of best practices. Institutions essentially impose structure and constraints on our activities, and our current institutional arrangements reflect the erroneous prevailing view that resources can be managed effectively and sustainably as discrete entities in isolation from the ecological, economic, and social systems in which they are embedded. This view is not only erroneous, it is disquieting because vibrant ecosystems underlie all economic and social gains. Improving and sustaining natural resource systems will require a reinvention of institutions that facilitate learning from a capacious perspective.

The Agreement was (and continues to be) hailed as a beacon of international cooperation in addressing shared environmental degradation at the time it was signed. At its signing in 1972, Canadian Prime Minister Pierre Trudeau said that the Agreement "promises to restore to a wholesome condition an immense area which, through greed and indifference, has been permitted to deteriorate disgracefully." We argue that this is remarkable for two reasons. First, the "ecosystem approach" was not yet conceived at the time (and would not be incorporated into the Agreement until 1978), and yet his reference to "a wholesome condition" was certainly a harbinger of a much more holistic and enlightened view of ecological problems and their solutions than was then available. Secondly, his reference to "greed and indifference" suggests a tone or attitude toward the utilitarian view of nature that has been, and continues to be, too slowly incorporated into our decision making models. We must build upon these two themes, to both further our understanding of the ecological systems upon which we are dependent, and address our attitudes regarding the human place in those systems so as to use that better understanding maximally to achieve a sustainable society.

The opportunity to shift programs and policies to achieve "a better understanding" as directed by the Agreement is an under-recognized opportunity. As we all engage in the review of the Agreement, we must seize this opportunity to renovate our management practices, to achieve gains in our knowledge, and commit to continually re-inspecting and adjusting our management paradigms.

Literature Cited

Botts L, Muldoon P. 2005. The Evolution of the Great Lakes Water Quality Agreement. Michigan State University Press.

Bowerman WW, Carey J, Carpenter D, Colborn T, DeRosa C, Fournier M, Fox GA, Gibson BL, Gilbertson M, Henshel D, McMaster S, Upshu R. 1999. Is it time for a Great Lakes Ecosystem

Management Agreement separate from the Great Lakes Water Quality Agreement? Journal of Great Lakes Research, 25: 237-238.

IJC [International Joint Commission]. 2001. Priorities 1999–2001: priorities and progress under the Great Lakes Water Quality Agreement. Science Advisory Board, Chapter 2. Accessed 15 October 2005 at [http://www.ijc.org/rel/boards/sab/pr9901/index.html].

IJC [International Joint Commission]. 2003. Priorities 2001–2003: priorities and progress under the Great Lakes Water Quality Agreement. Science Advisory Board, Chapter 5. Accessed 15 October 2005 at http://www.ijc.org/php/publications/pdf/ID1568.pdf.

Krantzberg G. 2004. Science must inform Great Lakes policy. Journal of Great Lakes Research, 30: 573-574.

Minns CK, Kelso JRM. 2000. NO! It is time for a Great Lakes Ecosystem Management Agreement that subsumes the Great Lakes Water Quality Agreement. Journal of Great Lakes Research, 26: 1-2.

CHAPTER TWO

AN APPRAISAL OF POLICY IMPLEMENTATION DEFICITS IN THE GREAT LAKES[3]

> A wise policy-maker... expects that his policies will achieve only part of what he hopes and at the same time will produce unanticipated consequences he would have preferred to avoid.
>
> —C.E. Lindblom, 1959
> *The Science of 'Muddling Through'*

Abstract

Understanding of the complexities of both public policy implementation and Great Lakes restoration has grown in sophistication since the 1970s. The Great Lakes Water Quality Agreement is the principal policy for reversing environmental decline in the region. Implementation of this and related policies, particularly by the federal governments, suffers from acute and chronic deficits that we summarily document. These policy implementation deficits will continue to frustrate efforts to revitalize the Great Lakes unless significant advances are made to design governance processes within the Great Lakes regime that accommodate the complexity of linked social and ecological systems. The 2010-2011 governmental process to renegotiate the Great Lakes Water Quality Agreement is a potent opportunity to begin to overcome institutional barriers to reducing policy deficits. We argue that the renegotiation must begin a reinvestment in remaking or reimagining Great Lakes institutions in a way that restores capacity, flexibility, and moral authority. Our purpose is to help provide a foundation for that discussion.

Keywords

Great Lakes Water Quality Agreement; policy implementation deficit; governance; institutions; reform; renewal

Introduction

Understanding and explaining the phenomenon of public policy implementation has been a formal theme of policy studies since the 1970s. Similarly, understanding and reversing the decline

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of the Great Lakes has been a formal policy of the governments of Canada and the United States—manifest principally in the Great Lakes Water Quality Agreement—since the 1970s. That understanding has since grown in sophistication as research has helped us begin to appreciate the complexity of systems and to abandon simplistic models of causality and behaviour—both with respect to implementation research (e.g., Hill and Hupe, 2002; Winter, 2003) and Great Lakes restoration (e.g., Francis and Regier, 1995; Bails et al., 2005).

Much of this change has resulted from an evolution in how we perceive the behaviour of both human systems and environmental systems (Holling and Meffe, 1996; Scoones, 1999; Norberg and Cumming, 2008). This evolution has shown the complex and adaptive properties of systems to be common in arrangements of both people (e.g., Lansing, 2003; Ostrom, 2005) and nature (e.g., Levin, 1999; Gunderson 2000). Those changes in perception, however, appear not to have affected deeply the implementation of natural resources policy (Regier et al., 1999; Ladle and Gillson, 2009), and subsequently, governance regimes with insufficient sophistication are failing to sustain resources (Lemos and Agrawal, 2006).

Natural resource management has been based traditionally on an implicit assumption that the systems being managed are relatively simple or mechanistic and can be easily bounded (Holling and Meffe, 1996). Where this assumption eschews consideration of the inherent uncertainty and unpredictability of complex systems, a lack of appreciation for feedbacks and secondary effects from our extractive activities and management interventions has resulted (Walker and Salt, 2006). Holling et al. (1998) called the resulting unforeseen and unintended consequences (i.e., "surprises") the gaps between the results we expect and the realities we perceive. Similarly, where early policy studies had been "obsessed" with how policy was developed, outcomes were assumed to materialize as envisioned and the "practical details" of actual implementation were therefore largely ignored (Gunn, 1978).

Pressman and Wildavsky (1973) were the first to critically assess the causal linkages associated with policy goals and practical outcomes and call this specifically a study of implementation. Examining a federally-mandated U.S. program of economic development and job creation in California, they were interested in understanding the extent to which successful implementation depended upon relationships between various implementing organizations and departments. They described the success of a policy as being dependent upon a number of links in an "implementation chain", arguing that the degree of cooperation between agencies required to make those links was necessarily very close to one hundred percent. Where this percentage is consistently less than one hundred, they suggested, the accumulation of small deficits can create a large shortfall in successful outcomes.

Unfortunately, the conclusions in Pressman and Wildavsky's (1973) book *Implementation* were not encouraging. The program they investigated failed utterly despite its noble inten-

tions, and they consequently subtitled their book: *How Great Expectations in Washington are Dashed in Oakland; or Why It's Amazing that Federal Programs Work At All, This Being a Saga of the Economic Development Administration as told by Two Sympathetic Observers who Seek to Build Morals on a Foundation of Ruined Hope.* Their idea of an implementation deficit began to diminish the widespread assumption that the path from goal setting to achievement was routinely simple, predictable, and automatic. Hill (2005) explains that *Implementation* reflected public frustration with the failure, or limited success, of the 1960s war on poverty in the United States and the recognized gap between federal program aspirations and local social realities.

In their comprehensive history of federal aspirations and local realities under the Agreement, Botts and Muldoon (2005) document how implementation of the Agreement has produced such deficits, and disappointment and disengagement as a result. By the late 1990s, they observe, incomplete results were contributing to a growing dissatisfaction with progress under the Agreement, and significantly, that the ways in which its goals were being pursued were beginning to be questioned (also Sproule-Jones, 2002).

The creation of conditions for ordered, collective action—such as the collaborative restoration of regional water quality and ecological health—is a matter ultimately of governance (Stoker, 1998), and governance has been implicated in the continuing persistence of significant deficits in the Agreement's implementation (e.g., Botts and Muldoon, 2005; Krantzberg et al., 2007, 2008; Jackson and Sloan, 2008). The 2010-2011 governmental renegotiation of the Agreement, the first since 1987, is a watershed opportunity to enhance significantly our capacity to address ecological *and* institutional threats to further progress in Great Lakes restoration (Krantzberg, 2009). Our purpose is to draw attention to aspects of the Agreement's implementation deficit that we believe will continue to impede achievement of its purpose in significant ways. We present empirical evidence of the shortcomings of the Agreement's implementation that illuminate the nature and breadth of the problems of governance that must be addressed with a binational commitment to contemporary governance renewal processes (such as the 2010-2011 Agreement renegotiation). We argue that Great Lakes governance at present is grossly inadequate to understand and respond to diffuse and nonlinear changes occurring presently in the Great Lakes (e.g., Bails et al., 2005), and that to reduce deficits in implementation of the Agreement significantly will require a dramatic shift in the "mindscape" of the Great Lakes regime (Regier et al., 1999).

Background

Our analysis of limiting factors in governance related to achieving the goals of the Agreement considers the types of indicators or measureable outcomes associated with the goals for Great Lakes restoration. The general water quality objectives of the initial 1972 Agreement, for exam-

ple, called for the Great Lakes to become "free from substances... in concentrations that are toxic or harmful to human, animal or aquatic life" (United States and Canada, 1972). The 1978 Agreement directed that the "discharge of any or all persistent toxic substances be virtually eliminated" (United States and Canada, 1978). Intended results of the Agreement's implementation are identified in Articles II, III, IV, and VI, as well as throughout the Annexes, and are considerably specified in Annexes 1 and 3. As a general assessment, however, the IJC (2006b) reports that the Agreement's "objectives often go unmet within specified timelines," and even then, "the Agreement does not go beyond committing the Parties to make best efforts to achieve them." Further, targets in the Agreement's Articles and Annexes are increasingly outdated and irrelevant, or relevant but unmet (IJC, 2006a; SAB, 2008). And with the exception of the phosphorus loading targets in Annex 3, there has been an increasing shift away from those goals in the focus of the Parties that further undermines the Agreement's relevancy (Botts and Muldoon, 2005). The reasons for these shortcomings are not scientific in nature, but rather speak to an overarching notion of a growing, cumulative deficit where cooperation is 'less than perfect' and goals are only rarely if ever fully attained. One way of analyzing implementation deficits is to think about what "perfect" implementation would require (Hood, 1976). Gunn (1978) asked "why is implementation so difficult?" and structured an answer in the form of ten preconditions for "perfect" implementation (also Hogwood and Gunn, 1984). Below we repeat Gunn's (1978) ten preconditions as subsection headings and provide select evidence of Agreement-related deficits for each.

Discussion

The following ten subsection headings are preconditions for "perfect" public policy implementation (Gunn, 1978; also Hogwood and Gunn, 1984). The text associated with each subsection heading provides evidence to describe various deficits in implementing the Great Lakes Water Quality Agreement and how the examples given represent "imperfect" implementation. These results are meant to be illuminating and not comprehensive.

Circumstances external to the implementing agency do not impose crippling constraints.

By their uncertain nature, the complex systems being managed pose significant external threats to the sustained human use of those systems due to their potential to 'impose crippling constraints' on management options (e.g., Holling, 1996). Sources of overwhelming uncertainty such as climate change create "wicked problems" (Rittel and Webber, 1973)—i.e., problems that are without definitive and final formulation, where each is unique and has no stopping rule (meaning that in a sense you can never *know* the problem entirely). For this reason, inherent

uncertainties create *chronic* deficits in policy implementation that are permanent features of management in complex systems (after Hogwood and Peters, 1985, whose use of "chronic disorder" extends the medical analogy of pathology, the study of the nature of disease and its structural and functional effects on the body, to "understand the disorders which governments encounter in making and implementing public policy"). Such chronic deficits can be reduced but not eliminated (after Holling, 1996)—and even then, reductions require techniques to reduce uncertainty through its proper treatment by rigorous decision-making processes (Lindley, 2006).

Scientific uncertainty is a dominant, chronic feature of Great Lakes management (Regier et al., 1999) inherent in contemporary issues such as climate change (Kling et al., 2003), atmospheric deposition of toxics (Blumberg et al., 2000), interactions of invasive species now present with native ecologies and the introduction of new invasive species (SAB, 2006), and the increasing settlement and movement of people and resultant land uses and alterations (IJC, 2004). These various stresses on the ecological function of the Great Lakes threaten to undermine the internal self-regulating mechanisms that drive ecosystem services (Bails et al., 2005; Rapport et al., 1985). The primary focus of the program for restoration of the Great Lakes as embodied principally by the Agreement should be on protecting those mechanisms from significant deterioration. We agree with Mackey (2010), that reaching this goal will require the Great Lakes regime to "adopt a different paradigm" that focuses on learning about ecosystem needs and thresholds and that seeks to reduce uncertainty as a constraint on the efficacy of management interventions.

Policy implementation deficits can also be *acute* where the ingrained behaviours of organizations and conflicting political agendas create political uncertainty that undermines the continuation and efficacy of management interventions. These deficits are not necessarily chronic, however, as they can be reduced to the extent that people do have agency in their decisions and actions to ensure sustained funding or promote collaborative approaches, for example. In the Great Lakes, constraints that create acute deficits can be social factors such as competing problem definitions and political priorities that potentially inhibit policy processes and the achievement of policy outcomes. For example, fundamental disagreements between AOC stakeholders about the scope of Remedial Action Plans (RAPs), and the partial or complete withdrawal of federal or subnational funding for RAPs in both countries during the 1990s contributed to a lack of implementation and a loss of public enthusiasm (Botts and Muldoon, 2005; IJC, 2003b; Krantzberg, 2002, 2003; OPAC, 2006). Where these factors dominate, there is little that those carrying out policy can do to overcome them (Gunn, 1978).

Chronic deficits in policy implementation may be more difficult to mitigate because with time they become an accepted fact of life and less likely to attract appropriate attention, whereas acute deficits often represent "crises" that tend to attract disproportionate political or

public attention (Hogwood and Peters, 1985). Such crises are inevitable consequences of managing in complex systems where a different (i.e., more favourable) system response to management interventions was expected (Holling 1996). We appear to have difficulty appreciating where surprising outcomes in managed systems result from unsustainable management actions that manifest as real or perceived crises (Gunderson et al., 2006; Holling, 1986; Holling and Meffe, 1996). Hogwood and Peters (1985) suggest that there is a human tendency (or perhaps congenital difficulty) in dealing with complexity to try explaining every observed phenomenon with a single cause and thereby discount the significance of underlying deficits and disorders in policy implementation. To the extent that this describes a tendency of Great Lakes governance, it is in spite of a lengthy commentary on appropriate institutional responses to complexity (e.g., Francis et al., 1979; Regier and Baskerville, 1986; Francis and Regier, 1995; Regier et al., 1999; Vallentyne, 1999; Bails et al., 2005; MacDonagh-Dumler et al., 2009; Krantzberg et al., 2008; Krantzberg, 2009).

Adequate time and sufficient resources are made available to the programme.

Policies that are otherwise feasible in that they (to some degree) overcome crippling constraints may still fall well short of intentions. Gunn (1978) suggests that financial restrictions, for example, commonly starve policy programs of adequate resources. Botts and Muldoon (2005) document how the governments have demonstrated a "diminished commitment to and overt complacency" to the Agreement, and how funding for research and science in both countries has continued to decrease (also Krantzberg, 2003; WQB, 1998). The Canadian federal government's 1995 so-called program review budget, for example, reduced expenditures on federal departments including environment, agriculture, natural resources, and fisheries and oceans by a combined 31.2% over three subsequent years (Department of Finance, 2008). A new provincial government in Ontario that same year made cuts of 68% to operating funds for the provincial ministries of environment and natural resources from a high only six years earlier (Krajnc, 2000). These events "conspired against" the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem on intergovernmental Great Lakes cooperation reaching its potential because key federal and provincial agencies "simply walked away from their obligations" (Winfield and Jenish, 1999). At present, the Canadian federal government's Great Lakes Action Plan remains at $8-million (CDN) per year "to protect the Great Lakes by cleaning up areas identified as being the most degraded" (Environment Canada, 2010).

Gunn (1978) also suggests that too much can be expected too soon, especially when changes in attitudes or behaviours are required. This is common where funds are available only within an unrealistically short time, shorter than the program can effectively absorb them. Be-

yond more immediate issues of decreased funding, there is a general disconnection between scientific and political assumptions and timelines in the Great Lakes that routinely creates misplaced expectations about the certainty of science-based information and the rate of return on funds for scientific study (Regier et al., 1999; Krantzberg, 2004). What will become of the Great Lakes Restoration Initiative—the Obama Administration's ongoing 2010 budget initiative of $475-million (USD) to clean up toxic sediment, restore nearshore habitat, and fight invasive species by targeting "shovel ready" projects (Koslow, 2009)? The GLRI's first-year financial commitment, however welcome, pales in comparison to the estimated $20 billion (USD) required to rehabilitate all AOCs in the Great Lakes (Flesher, 2009). Months before the 2010 U.S. midterm elections, the Obama Administration acknowledged that measurable results from those initial seeded projects would need to be swift in order to help ensure that GLRI funding would continue into the second of a proposed ten years (Davis, 2010). Uncertainty for that funding is increased given the results of those midterm elections (e.g., Boodhoo, 2010). The history of RAP implementation (as documented recently by Botts and Muldoon, 2005) does not suggest that the Administration's requirement of "accountability" and sense of "urgency" (Davis, 2009) are qualities that can be commanded of a complex process over the course of several months.

Not only are there no constraints in terms of overall resources but also that, at each stage in the implementation process, the required combination of resources is actually available.

Gunn (1978) suggests that "acute bottlenecks" can develop in complex programs when an essential sequence of funding is not made available. For example, Remedial Action Plans (RAPs) were a unique addition of the Agreement's 1987 Protocol meant to remediate dozens of the most contaminated geographic locations in the Great Lakes, particularly in urban harbours and connecting channels, through the collaborative efforts of government, industry, and local stakeholders. Securing the resources required of a multi-stage process was a a key challenge in implementing RAPs and restoring beneficial uses, however, and "slow progress was a major disappointment almost from the beginning" where a "lack of committed resources at all levels of government was a continuing problem" (Botts and Muldoon, 2005; also OAG, 2001; GAO, 2003; IJC, 2003a).

The policy to be implemented is based upon a valid theory of cause and effect.

The 1972 Agreement was principally devised to address a nutrient pollution problem that had received wide and sustained media and public attention (Botts and Muldoon, 2005). Scientific studies established causal links between policy recommendations for significant

wastewater treatment expenditures and subsequent improvements in water chemistry that created early and significant progress in meeting those initial water quality targets (Bails et al., 2005; Botts and Muldoon, 2005). These events fit a rather predictable cause and effect pattern, however, where problem solution closely follows problem identification and where we have traditionally assumed such predictable behaviour from complex systems (Holling and Meffe, 1996). Management based on this assumption, however, creates a perverse and increasing like-lihood of unexpected events and eventual failure to provide ecosystem services to dependent human and other communities (Holling and Meffe, 1996).

In the Great Lakes, that predictability is increasingly uncertain. Numerous symptoms of stress have been identified beyond troubling nutrient loadings—such as the frequent detection of chemicals of emerging concern, declines in populations of numerous organisms, and toxic contamination of fish and humans—but specifying their diffuse causes is proving difficult (Bails et al., 2005). We have discovered, for example, that a resurgence of *Cladophora*, traditionally controlled by phosphorus limitation, no longer appears as straightforward as first believed. This resurgence is occurring in some coastal zones while offshore phosphorus concentrations remain low, the implications of which for research and management are undefined (Hecky et al., 2004). Beaches around the Great Lakes are often closed to the public despite that we have significantly addressed the presumed cause—combined sewer overflows (CSO)—of ongoing shoreline water contamination. Where the contamination remains after expensive remedial action has been taken to capture CSOs, causes remain elusive because multiple sources of local, persistent con-tamination appear to confound routine beach and other monitoring and prevent us from iden-tifying regional pollution from other sources (McLellan et al., 2003; also e.g., Edge and Hill 2007; Charlton, 1997). Further, the stressors that scientists in the public health community are worried about are not necessarily what is being measured (Sandra McLellan, University of Wisconsin, pers. comm.; Manno and Krantzberg, 2008).

The relationship between cause and effect is direct and there are few, if any, intervening links.

It is not only emerging problems that are troubling Great Lakes restoration: Lake Erie is again exhibiting some "disturbing trends" with respect to nutrient enrichment, for example, where earlier the problem was thought to have been solved (Environment Canada, 2001). This is one of many circumstances where it now appears that the relationship between cause and effect in issues of Great Lakes decline and restoration has become less direct—i.e., mechanisms are less clearly understood or hardly at all—and where the types and intensity of stressors have increased so that the symptoms now "appear stepwise like a chain reaction or self-organize in a complex, ecologically degraded manner" (Bails et al., 2005; also IJC, 2004; Koonce et al., 2010).

Pressman and Wildavsky (1973) suggested that the rules of probability equate a greater number of links in the policy implementation chain with a greater risk that some actions will prove poorly conceived or badly executed. This risk has proven problematic for the ability of the Great Lakes regime to adequately reflect and incorporate a management approach to the afore-mentioned likelihood of unexpected events and eventual system failure. In the presence of inherent uncertainty and confounding factors (and therefore, conversely, in the absence of unequivocal cause and effect relationships), we face deficit conditions that cannot be resolved entirely. These conditions therefore require an "appropriate paradigm" within which we can adequately assess and manage in the presence of that uncertainty (Mackey, 2010). It is troubling therefore that the governments' own Binational Executive Committee (BEC), for example, is "essentially dysfunctional" in that "it is not strategic and does not use SOLEC [the governments' own State of the Lake Ecosystem Conference] reporting to inform programs and policies in meeting the purpose of the Agreement" (Krantzberg et al., 2007; also Krantzberg et al., 2008; Barr et al., 2010). This is in part because SOLEC is not structured to evaluate the degree to which the Parties are meeting the Purpose of the Agreement. BEC has also not addressed these defi-ciencies in SOLEC in a way that SOLEC could be a useful instrument for understanding the rela-tionship between a management intervention and its outcome (i.e., cause and effect). Further evidence of this inability to clearly map the relationship between cause and effect—even if this relationship was straightforward and easily recognized—is the continuing absence of an ade-quate monitoring system. This follows the GAO (2003) determination that the monitoring sys-tem required under the Agreement to measure restoration progress "has not progressed to the point that overall restoration progress can be measured or determined" and that recent assess-ments of overall progress "do not provide an adequate basis for making an overall assessment." Furthermore, climatic changes (Magnuson et al., 1997) and new biological invasions (Dermott 2001) in the Great Lakes present new uncertainties for sustaining resources currently under management, as aging infrastructure built following the initial 1972 Agreement is increasingly unable to handle new emerging sources of stress such as viruses and pharmaceuticals entering the waters of the Great Lakes in wastewater at a landscape scale (IJC, 2002).

There is a single implementing agency which need not depend upon other agencies for success or, if other agencies must be involved, that the dependency relationships are minimal in number and importance.

Pressman and Wildavsky (1973) described a complex scenario involving one federal, one state, and one municipal government, and a single implementing agency—and yet there were 70 clearances (i.e., individual acts of consent) and 30 decision points (i.e., required acts of agree-ment) in their Oakland case study of a single, relatively small program. Governance of the Great

Lakes is bewilderingly and problematically unruly in contrast. Along with the two federal Parties with primary responsibility for fulfilling the Agreement's mandate, the number of governmental agencies and others with some degree of responsibility for Great Lakes programming is "overwhelmingly large" (Francis and Regier, 1995; also Jones and Taylor, 1999). At the very least, two Canadian provinces and dozens of legislative ridings, eight U.S. states and dozens of congressional districts, hundreds of municipal and other lower-tier governments, dozens more First Nations and Tribes, a diversity of non-governmental organizations and innumerable individual citizens are involved. Far from meeting this precondition, in fact, the overall structure and functioning of the Great Lakes regime cannot be fully comprehended (Francis, 1986).

There is complete understanding of, and agreement upon, the objectives to be achieved, and that these conditions persist throughout the implementation process.

In moving towards agreed upon objectives it is possible to specify, in complete detail and perfect sequence, the tasks to be performed by each participant.

Gunn (1978) suggests that objectives should be clearly defined, specific and preferably quantified, comprehensively agreed to and understood, mutually compatible and supportive, and provide a blueprint against which policy implementation can be monitored. But Botts and Muldoon (2005) describe an historic conflict between Agreement objectives and domestic agency objectives, and a continuing disagreement over responsibility for the mandates necessary to achieve both. This scenario is not the foundation upon which to base collective decisions and activities. The withdrawal of the Parties from some elements of the Agreement's program has also meant that the relationships between the goals of organizations and processes within the regime "are not always as clear as in the past" (Botts and Muldoon, 2005). Our own unpublished data from a survey of stakeholders with first-hand experience in RAP development and implementation, for example, suggest that the process suffered from "scope creep"—the continual layering on of new issues and elements to the plan (McLaughlin and Krantzberg, unpub ms). Although those same data record a somewhat positive view of the comprehensiveness of RAP development, the lack of agreed objectives was seen as a limitation to successful implementation of those plans. Further, the 'blueprint' as it exists in the Great Lakes has been poorly coordinated and monitoring of policy implementation wholly inadequate (OAG, 2001; GAO, 2003; McLaughlin and Krantzberg, 2006) despite longstanding calls for a strategic approach to understanding and managing the organizational complexity of the Great Lakes (e.g., Francis, 1987).

Objectives of organizations or programs are also often difficult to identify or are couched in vague and evasive terms, according to Gunn (1978), and even 'official' objectives may be in-

compatible with each other and with 'unofficial' goals that can be proliferated by self-interests. The nature of this conflict is highlighted by the experience with defining and implementing the 'ecosystem approach' introduced by the 1978 Agreement (e.g., Lee et al. , 1982; Vallentyne, 1999). Conflict over the ecosystem approach and what 'ecosystem-based management' entails for actual programs remains problematic (Slocombe, 2010), and in the Great Lakes is hampered by a general leadership malaise over the life of the Agreement that can be characterized in part by a governmental "reluctance" to accept responsibility for fulfilling Agreement obligations (GAO, 2003; also OAG 2001). The "struggle" to provide meaningful indicators through the SOLEC process is an example of this disinclination (Botts and Muldoon, 2005), an observation under-scored recently by an expert panel report that concluded that SOLEC lacks clarity and consis-tency, has failed to develop meaningful causal analyses and to identify key data and knowledge gaps, and that numerous indicators lacking endpoints makes their interpretation impossible (Barr et al., 2010). The end result, the panel states, is that the data are not suitable to inform on ecological status or management decisions.

There is perfect communication among, and coordination of, the various elements or agencies involved in the programme.

Lack of adequate communication and coordination by the lead agencies of the govern-ments has been a chronic problem of the Great Lakes governance regime (Botts and Muldoon, 2005; GAO, 2003; OAG, 2001). Failure to adequately meet this precondition underscores the importance of a "cumulative lesson learned" over the life of the Agreement, that Great Lakes protection "can only be accomplished by better coordination" but that "results have been mixed, and more effective coordination mechanisms are needed" (Findlay and Telford, 2006). A report for the Council of Great Lakes Governors also suggested that "the Great Lakes could be better served through coordinating efforts among federal, state, local, and binational policies that serve" multiple and often competing uses (Policy Solutions Ltd., 2004). Communication ef-forts by the lead agencies of the governments have also been harshly criticized—in particular that the SOLEC process represents a "failure of communication" that does not provide "mean-ingful information in a form that can be used... in a way that leads to appreciation for progress or reasons for deterioration" (Botts and Muldoon, 2005).

Those in authority can demand and obtain perfect obedience.

Finally, Gunn (1978) suggested that the precondition for perfect implementation per-haps least attainable occurs where "those 'in authority' are also those 'in power' and that they

are able to secure total and immediate compliance from others (both internal and external to the agency) whose consent and co-operation is required for the success of the programme." One administrative example of this lack of 'obedience' is in the fact that Canada and the United States possess fundamentally different political and legislative processes. The nature of compliance is therefore different in each country. For example, under the constitutional framework in Canada, the federal government cannot dictate Ontario's regulatory, investigative, enforcement, monitoring, and other Great Lakes programmatic policies. This is unlike in the U.S. where, for example, the Environmental Protection Agency can direct actions and priorities at the state level. (The states cannot be 'perfectly obedient', however, if they are not provided with resources adequate to the tasks being directed to them.) Secondly, a regulatory authority can demand a particular performance standard from a sector (such as an industry), but the outcome can still result in failure to comply. A third example is ecosystemic rather than administrative: that those in authority can dictate an intervention in the environment in order to obtain a certain outcome (e.g., in the delivery of ecological goods and services), but the environment does not respond as we had presumed it would.

The Agreement has provided a "code of conduct" that allows for "different, often overlapping, interests and opinions as to how those goals and objectives ought to be met" in each jurisdiction (Botts and Muldoon, 2005). Indeed, Gunn (1978) suggested that most of us would not want to live in a system that did not make such allowances, and why perfect implementation could not be pursued at all costs, including social and political costs. The contrast between the 'demands' of inflexible management and the 'allowances' of the Agreement also underscores the fact that the attainment of 'perfect implementation' is an authoritative illusion. It is also a distraction, because in dealing with wicked problems it makes no sense to seek "optimal solutions" (Rittel and Webber, 1973).

Conclusions

The complex challenges posed by deficits in implementation of the Great Lakes Water Quality Agreement illuminate deficiencies in how we conceptualize the dynamics of social-ecological systems, and how we formulate approaches to policy and problem-solving to cope effectively with those dynamics.

Our collective response to threats to ecological function and the revitalization of ecosystem resilience in the Great Lakes requires an institutional arrangement capable of better reconciling the complex of competing political authorities, pressures, priorities, and points of view. But in remodelling governance, consider that such deficits are to be expected, in that they are so often due to social-ecological behaviours that cannot be fully predicted (e.g., Gunderson and Holling, 2002; Norberg and Cumming, 2008). A "wise" policy-maker therefore expects that poli-

cies will only partially achieve intended outcomes and, at the same time, implementation of those policies will produce unanticipated consequences that would be avoided preferably (Lindblom, 1959). In fact, Gunn (1978) stated that the ten preconditions are not realistically attainable and therefore "perfect" implementation is an "unreal" concept. Instead, Gunn (1978) suggested that the ten preconditions were advanced to help us think more systematically about the reasons for implementation failures and about approaches to improving the implementation process—and, that we should concern ourselves with exploring the *idea* of perfect implementation, but not necessarily consider it an achievable *ideal*. As the renegotiation proceeds through 2011, however, it is uncertain if the process and outcomes will adequately reflect such a systematic exploration. Regardless, these types of analyses and reforms are necessary for substantive improvements in governance and policy implementation, and they must be considered integral to the Great Lakes policy regime whether incorporated into a renewed Agreement or not.

Governance is the human component of the ecosystem approach, and in the Great Lakes it is significantly disintegrated. The root of this seemingly intractable problem—that various responsible authorities fail to adequately coordinate their Great Lakes commitments—is that "their parts are not committed to the whole," and that the "ecosystem approach to policy will not be pursued unless it receives a priority commensurate with its importance for a sustainable future" (Caldwell, 1994). We have presented key evidence to illustrate where implementation of the Agreement has fallen short of achieving its purpose and the objectives of its articles and annexes—but more importantly, that the coordination and priority for fundamental and lasting results is absent. This is due, at least in part, to the incongruity between traditional approaches that continue to dominate natural resource management agencies and the reality of complex adaptive systems in which the interactions of humans and their environment are neither entirely within our control nor entirely predictable. A full embrace of these realities in the programs and protocols of a renewed Agreement and throughout the Great Lakes regime is required if we are to see significant improvement in the state of the Great Lakes and their long-term sustainable outlook.

Literature Cited

Adams M. 2003. Fire and Ice: The United States, Canada and the Myth of Converging Values. Penguin Canada.

Bails J, Beeton A, Bulkley J, DePhilip M, Gannon J, Murray M, Regier H, Scavia D, 2005. Prescription for Great Lakes Ecosystem Protection and Restoration: Avoiding the Tipping Point of Irreversible Changes. Wege Foundation and Joyce Foundation. Accessed 29 Jan 2011 at http://nsgl.gso.uri.edu/michu/michui05009.pdf.

Barr J, Hall TJ, Harris HJ, Krantzberg G, Sowa S, 2010. Review Report of the SOLEC Independent Expert Panel. Presented to Environment Canada and the U.S. Environmental Protection Agency. Accessed 30 Nov 2010 at http://msep.eng.mcmaster.ca/epp/publications.html.

Blumberg K, Botts L, Brown, TH, Holsen TM, Johnson A. 2000. Atmospheric Deposition of Toxics to the Great Lakes: Integrating Science and Policy. Delta Institute.

Boodhoo N. 2010. Changing gears: what does Republican control mean for the Great Lakes? Accessed 25 Nov 2010 http://www.wcpn.org/WCPN/news/32785.

Caldwell L. 1994. Disharmony in the Great Lakes Basin: institutional jurisdictions frustrate the ecosystem approach. Alternatives, 20.3: 26-31.

Charlton M. 1997. The sewage issue in Hamilton Harbour: implications of population growth for the remedial action plan. Water Quality Research Journal of Canada, 32: 407-420.

Davis C. 2009 [Oct 7]. Canada – U.S. Great Lakes Water Quality Agreement. Keynote address to the International Joint Commission Biennial Meeting, Windsor, Canada. Accessed 12 May 2010 at http://epa.gov/greatlakes/live/IJC_Davis.html.

Davis C. 2010 [May 20]. Using Science to Guide Great Lakes Restoration. Keynote Address to the International Association for Great Lakes Research Conference, Toronto, Ontario, Canada.

Department of Finance. 2008 [Apr 29]. Budget 1995: Fact Sheet. Government of Canada. Accessed 9 Oct 2010 at http://www.fin.gc.ca/budget95/fact/FACT_6-eng.asp.

Dermott R. 2001. Sudden disappearance of the amphipod Diporeia from Eastern Lake Ontario, 1993–1995. Journal of Great Lakes Research, 27: 423-433.

Edge TA, Hill S. 2007. Multiple lines of evidence to identify the sources of fecal pollution at a freshwater beach in Hamilton Harbour, Lake Ontario. Water Research, 41: 3585-3594.

Environment Canada. 2010. Great Lakes Action Plan. Accessed 20 Dec 2010 at http://www.ec.gc.ca/grandslacs-greatlakes/default.asp?lang=En&n=DF30B51A-1.

Environment Canada. 2001. Lake Erie: A Lake In Flux. Accessed 25 Jan 2010 at http://www.on.ec.gc.ca/laws/coa/2001/lake-erie-e.html.

Findlay R, Telford P. 2006. The International Joint Commission and the Great Lakes Water Quality Agreement: Lessons for Canada-United States Regulatory Co-Operation. Government of Canada, Policy Research Initiative, Working Paper Series 023.

Flesher J. 2010. EPA appoints czar for Great Lakes clean up. USA Today. Accessed 5 Jun 2010 http://www.usatoday.com/tech/science/environment/2009-06-05-great-lakes_N.htm.

Francis G. 1986. Great Lakes governance and the ecosystem approach: where next? Alternatives, 13.3: 61-70.

Francis G. 1987. Toward understanding Great Lakes "organizational ecosystems". Journal of Great Lakes Research 13, 233.

Francis GR, Magnuson JJ, Regier HA, Talhelm DA, editors. 1979. Rehabilitating Great Lakes Ecosystems. Great Lakes Fishery Commission, Technical Report No. 37.

Francis GR, Regier HA. 1995. Barriers and bridges to the restoration of the Great Lakes Basin ecosystem. In: Barriers and Bridges to the Renewal of Ecosystems and Institutions. Gunderson LH, Holling CS, Light SS, editors. pp. 239-291. Columbia University Press.

GAO [United States General Accounting Office]. 2003. Great Lakes: An Overall Strategy and Indicators for Measuring Progress are Needed to Better Achieve Restoration Goals. Report GAO-03-515.

Gunderson LH, Carpenter SR, Folke C, Olsson P, Peterson GD. 2006. Water RATs (resilience, adaptability, and transformability) in lake and wetland social-ecological systems. Ecology and Society, 11.1: art16.

Gunderson LH, Holling CS, editors. 2002. Panarchy: Understanding Transformations In Human and Natural Systems. Island Press.

Gunderson LH. 2000. Ecological resilience—in theory and application. Annual Review of Ecology and Systematics, 31: 425-439.

Gunn L. 1978. Why is implementation so difficult? Management Services in Government, 33: 169-176.

Hecky RE, Smith REH, Barton DR, Guildford SJ, Taylor WD, Charlton MN, Howell T. 2004. The near shore phosphorus shunt: a consequence of ecosystem engineering by dreissenids in the Laurentian Great Lakes. Canadian Journal of Fisheries and Aquatic Sciences, 61: 1285-1293.

Hill M. 2005. The Public Policy Process. Fourth edition. Pearson Longman.

Hill M, Hupe P. 2002. Implementing Public Policy: Governance In Theory and Practice. Sage.

Hogwood BW, Gunn L. 1984. Policy Analysis for the Real World. Oxford University Press.

Hogwood BW, Peters BG. 1985. The Pathology of Public Policy. Oxford University Press.

Holling CS. 1986. Resilience of ecosystems: local surprise and global change. In: Sustainable Development and the Biosphere. Clark WC, Munn RE, editors. pp. 292-317. Cambridge University Press.

Holling CS. 1996. Surprise for science, resilience for ecosystems, and incentives for people. Ecological Applications, 6: 733-735.

Holling CS, Berkes F, Folke C. 1998. Science, sustainability and resource management. In: Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Berkes F, Folke C, editors. pp. 342-362. Cambridge University Press.

Holling CS, Meffe G. 1996. Command and control and the pathology of natural resource management. Conservation Biology, 10: 328-337.

Hood C. 1976. The Limits of Administration. Wiley.

IJC [International Joint Commission]. 2002. Eleventh Biennial Report.

IJC [International Joint Commission]. 2003a. Emerging Great Lakes Issues in the 21st Century: 2001-03 Priorities Report. Great Lakes Science Advisory Board.

IJC [International Joint Commission]. 2003b. Status of Restoration Activities in Great Lakes Areas of Concern: A Special Report.

IJC [International Joint Commission]. 2004b. Twelfth Biennial Report.

IJC [International Joint Commission] 2006a. A Guide to the Great Lakes Water Quality Agreement: Background for the 2006 Governmental Review.

IJC [International Joint Commission]. 2006b. Thirteenth Biennial Report.

Jackson J, Sloan KK. 2008. A Way Forward: Strengthening Decision-Making and Accountability Under the Great Lakes Water Quality Agreement. Accessed 31 Oct 2008 http://www.glu.org/sites/default/files/Governance%20GLU%20Jan08.pdf.

Jones ML, Taylor WW, 1999. Challenges to the implementation of the ecosystem approach in the Great Lakes basin. Aquatic Ecosystem Health and Management 2, 249-254.

Kling GW, Hayhoe K, Johnson LB, Magnuson JJ, Polasky S, Robinson SK, Shuter BJ, Wande MM, Wuebbles DJ, Zak DR. 2003. Confronting Climate Change in the Great Lakes Region: Impacts on Our Communities and Ecosystems. Union of Concerned Scientists and Ecological Society of America.

Koonce JF, Findlay CS, Gannon JE, Barker NKS, Kang M, Ciborowski JJH. 2010. Weight of evidence for causes of re-eutrophication of the Great Lakes. Sixth Biennial Lake Erie Millennium Network Conference. Accessed 15 Sep 2010 at http://web2.uwindsor.ca/lemn/LEMN2010.htm.

Koslow M. 2009. Meetings detail restoration spending plan. Accessed 25 Jan 2010 http://www.glu.org/news/2009/09/meetings-detail-restoration-spending-plan.

Krajnc A. 2000. Wither Ontario's environment? neo-conservatism and the decline of the environment ministry. Canadian Public Policy, 26: 111-127.

Krantzberg G. 2002. Restoring active participation. Journal of Great Lakes Research, 28: 491-492.

Krantzberg G. 2003. Keeping remedial action plans on target: lessons learned from Collingwood Harbour. Journal of Great Lakes Research, 29: 641-651.

Krantzberg G. 2004. Science must inform Great Lakes policy. Journal of Great Lakes Research 30, 573-574.

Krantzberg G. 2009. Renegotiating the Great Lakes Water Quality Agreement: the process for a sustainable outcome. Sustainability 1, 254-267.

Krantzberg G, Manno J, De Boer C. 2007. Great Lakes St. Lawrence River Governance: Report on the Expert Workshop. Prepared for the Joyce Foundation. Accessed 30 Apr 2010 at http://msep.mcmaster.ca/epp/publications.html.

Krantzberg, G., McLaughlin, C., Manno, J., De Boer, C., 2008. Great Lakes Governance: Future Models, Present Solutions. Prepared for the Joyce Foundation. Accessed 30 Apr 2010 at

http://msep.mcmaster.ca/epp/publications.html.

Ladle RJ, Gillson L. 2009. The (im)balance of nature: a public perception time-lag? Public Understanding of Science, 18: 229-242.

Lansing JS. 2003. Complex adaptive systems. Annual Review of Anthropology, 32: 183-204.

Lee BJ, Regier HA, Rapport DJ. 1982. Ten ecosystem approaches to the planning and management of the Great Lakes. Journal of Great Lakes Research, 8: 505–519.

Lemos MC, Agrawal A. 2006. Environmental governance. Annual Review of Environment and Resources, 31: 297-325.

Levin S. 1999. Fragile Dominion: Complexity and the Commons. Perseus Books.

Lindblom CE. 1959. The science of 'muddling through'. Public Administration Review, 19: 79-88.

Lindley DV. 2006. Understanding Uncertainty. Wiley.

MacDonagh-Dumler J. 2009. Policy innovation for Great Lakes ecosystem management. Journal of Great Lakes Research, 35: 477-481.

Mackey, S.D., 2010. Climate change, water levels, adaptation, and the Lake Erie Ecosystem. Sixth Biennial Lake Erie Millennium Network Conference. Accessed 10 Oct 2010 at http://web2.uwindsor.ca/lemn/LEMN2010.htm.

Magnuson JJ, Webster KE, Assel RA, Bowser CJ, Dillon PJ, Eaton JG, Evans HE, Fee EJ, Hall RI, Mortsch LR, Schindler DW, Quinn FH. 1997. Potential effects of climate changes on aquatic systems: Laurentian Great Lakes and Precambrian shield region. Hydrological Processes, 11: 825-871.

Manno J, Krantzberg G. 2008. Rediscovering and revitalizing the Great Lakes governance. In: Governance for Sustainability: Issues, Challenges, Successes. Bosselmann K, Engel R, Taylor P, editors. pp. 159-170. IUCN Environmental Policy and Law Paper No. 70.

McLaughlin C, Krantzberg G. 2006. Toward a 'better understanding' of the Great Lakes Basin Ecosystem. Journal of Great Lakes Research, 32: 197-199.

McLellan SL, Salmore AK. 2003. Evidence for localized bacterial loading as the cause of chronic beach closings in a freshwater marina. Water Research, 37: 2700-2708.

Norberg J, Cumming GS. 2008. Introduction. In: Complexity Theory for a Sustainable Future. Norberg J, Cumming GS, editors. pp. 1-13.Columbia University Press.

OAG [Office of the Auditor General of Canada]. 2001. A legacy worth protecting: charting a sustainable course in the Great Lakes and St. Lawrence River basin; Chapter 1 of the Report of the Commissioner of the Environment and Sustainable Development. Public Works and Government Services Canada.

OPAC [Ontario Public Advisory Council]. 2006. Great Lakes Hotspots: Ontario Citizens Speak Up: Highlights. Ontario Public Advisory Council.

Ostrom E. 2005. Understanding Institutional Diversity. Princeton University Press.

Policy Solutions Ltd., 2004. Great Lakes Restoration and Protection Priorities: An Overview of Programs, Funding Streams, and Critical Gaps. Accessed 25 Jun 2010 at http://www.cglg.org/projects/priorities/docs/PolicySolutionsReport12-10-04.pdf.

Pressman JL, Wildavsky A. 1973. Implementation. University of California Press.

Rabe BG, Lowry WR. 1999. Comparative analyses of Canadian and American environmental policy: an introduction to the symposium. Policy Studies Journal, 27: 263-266.

Rapport DJ, Regier HA, Hutchinson TC. 1985. Ecosystem behaviour under stress. American Naturalist, 125; 617-640.

Regier HA, Baskerville GL. 1986. Sustainable redevelopment of regional ecosystems degraded by exploitive development. In: Sustainable Development of the Biosphere. Clark WC, Munn RE, editors. pp. 75-103. Cambridge University Press.

Regier HA, Jones ML, Addis J, Donahue M. 1999. Great Lakes–St. Lawrence River basin assessments. In: Bioregional Assessments: Science at the Crossroads of Management and Policy. Johnson KN, Swanson FJ, Herring M, Greene S, editors. pp. 133-165. Island Press.

Rittel HWJ, Webber MM. 1973. Dilemmas in a general theory of planning. Policy Sciences, 4: 155-169.

SAB [Great Lakes Science Advisory Board]. 2006. Expert Consultation on Emerging Issues of the Great Lakes in the 21st Century. International Joint Commission.

SAB [Great Lakes Science Advisory Board]. 2008. Priorities 2005-2007: Priorities and Progress Under the Great Lakes Water Quality Agreement. International Joint Commission.

Scoones I. 1999. New ecology and the social sciences: what prospects for a fruitful engagement? Annual Review of Anthropology, 28: 479-507.

Slocombe DS. 2010. Applying an ecosystem approach. In: Resource and Environmental Management in Canada: Addressing Conflict and Uncertainty. Mitchell B, editor. Fourth edition. pp. 409-433. Oxford University Press.

Sproule-Jones M. 2002. Restoration of the Great Lakes: Promises, Practices, Performances. UBC Press.

Stoker G. 1998. Governance as theory: five propositions. International Social Sciences Journal, 155: 17-28.

United States and Canada, 1972. The Great Lakes Water Quality Agreement.

United States and Canada, 1978. The Great Lakes Water Quality Agreement.

Vallentyne JR. 1999. Extending causality in the Great Lakes basin ecosystem. Aquatic and Ecosystem Health, 2: 229-237.

Walker B, Salt D. 2006. Resilience Thinking: Sustaining Ecosystems and People in a Changing World. Island Press.

Winfield M, Jenish G. 1999. Troubled Waters? A Review of the Performance of the Governments of Canada and Ontario Under the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem. Canadian Institute for Environmental Law and Policy.

Winter SC. 2003. Implementation perspectives: status and reconsideration. In: Handbook of Public Administration. Peters BG, Pierre J, editors. pp. 212-222. Sage.

WQB [Great Lakes Water Quality Board]. 1998. Review of Government Resources and Changing Program Thrusts as They Relate to Delivery of Programs Under the Great Lakes Water Quality Agreement. International Joint Commission.

CHAPTER THREE

AN APPRAISAL OF MANAGEMENT PATHOLOGIES IN THE GREAT LAKES[4]

> Many conservation treatments are superficial. ... In general, the trend of the evidence indicates that in land, just as in the human body, the symptoms may lie in one organ and the cause in another. The practices that we now call conservation are, to a large extent, local alleviations of biotic pain. They are necessary, but they must not be confused with cures.
>
> — Aldo Leopold, 1941
> *Wilderness as a Land Laboratory*

Abstract

Recent research has produced broad application of the health concept to regional ecosystems, including the Great Lakes. The attention is warranted, as new and recurring stresses on the health of the Great Lakes undermine our understanding and hinder our ability to manage for critical ecological functions. There is widespread agreement that the Great Lakes are presently exhibiting symptoms of extreme stress and potentially irreversible and catastrophic damage. Traditional 'command and control' management has resulted simultaneously in environmental benefits to people and a loss of resilience in the ecosystem. Surprising system responses prompt further control; the continued decline in resilience has been called the pathology of natural resource management. The pathology is also suggested to affect human systems of organization such as management authorities. We use published criteria of institutional pathologies to illustrate their occurrence in the Great Lakes, resulting in evidence of non-existent program evaluation, program incompatibility, lack of coordination among programs, authorities that establish and then abandon public participatory initiatives, and inappropriate choice of policy mechanisms or inadequate level of support for an appropriate mechanism (either of which creates disincentives for stakeholders). Learning is an element of resilience, as managed systems are inherently dynamic and our understanding is therefore always incomplete. Policy mechanisms that mimic learning techniques to improve understanding are therefore central to avoiding pathologies in management. But learning (individually or institutionally) can be threatening and very difficult, and its proper conduct necessarily involves a continuous process of feedback,

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[4] McLaughlin C, Krantzberg G. *In review*. An appraisal of management pathologies in the Great Lakes. Science of the Total Environment.

interpretation, and reformulation. Double-loop learning processes that institutionalize learning in policy are recommended, as these will be required to overcome pathologies in management and maintain resilience of the Great Lakes system.

Keywords

Great Lakes Water Quality Agreement, pathology of natural resource management, institutional culture, governance reform

Introduction

Recent research has produced broad application of the health concept to regional ecosystems (e.g., Clapcott et al., 2010; Foley et al., 2010; Paetzold et al., 2010), including the Great Lakes (e.g., Dobiesz et al., 2010; Marentette et al., 2010). The attention is certainly warranted, as new and recurring stresses on the health of the Great Lakes—including overfishing, nutrient loading, toxic chemicals and sediment, invasive non-native plant and animal species, and wholesale hydrologic alterations—undermine our understanding and hinder our ability to manage for critical ecological functions (Bails et al., 2005; IJC, 2006a; also Regier and Baskerville, 1986; Francis and Regier, 1995; Regier et al., 1999). Such stresses are the cumulative result of traditional 'command and control' management of the Great Lakes (Francis and Regier, 1995), the employment of which results simultaneously in environmental benefits to people and a loss of resilience in the ecological (and social) system (Holling, 1986, 1995; Holling and Meffe, 1996).

Resilience is a measure of the capacity for a complex system (such as a lake) to maintain a desirable state when perturbed by extractive uses, for example (Holling, 1973), and more broadly is the degree to which a social-ecological system is capable of self-organization, learning, and adaptation (e.g., Berkes et al., 2003). Resilience is also an element of ecosystem health (Rapport et al., 1998). (Of course, seriously degraded systems may also show resilience in maintaining an undesirable condition.) It is therefore critical that natural resource consumption and management strive to avoid such undesirable shifts in productive ecosystems past thresholds beyond which ecological health is critically diminished (Scheffer et al., 2001). The dependencies of human populations on social-ecological relationships demand this, and the widespread agreement that "the Great Lakes are presently exhibiting symptoms of extreme stress" with the potential to cause "irreversible and catastrophic damage" should therefore be of tremendous concern (Bails et al., 2005).

Our focus is on the institutional characteristics necessary to more effectively remedy existing damage to the health of the Great Lakes, and more generally develop governance mechanisms to cope with ongoing, variable, and unpredictable stresses. Institutions are

significant determinants of the trajectories of linked systems of humans and nature (Berkes et al., 1998; Berkes, 2002; Berkes et al., 2003; Young 2008), meaning that how governance is conceived and conducted plays a significant role in the health outcomes of social and ecological systems being manipulated. We contend that the recent history of water quality in the Great Lakes reflects this assertion—that institutions have figured both as causes of social-ecological problems and as mechanisms for addressing them. Institutional regimes with mandates for restoration should first do no harm, but the complex challenges of restoration are amplified, and can become overwhelming, when shortsighted and narrow-minded organizations fail to adjust to new knowledge and opportunities due to inflexibility and inattentiveness (Holling, 1995; Holling and Meffe, 1996)—circumstances that persist in the Great Lakes (Steedman and Regier, 1987; Bell, 1994; Francis and Regier, 1995; Regier et al., 1999; MacDonagh-Dumler, 2009).

Traditional management has sought "to control nature in order to harvest its products, reduce its threats, and establish highly predictable outcomes for the short-term benefit of humanity" (Holling and Meffe 1996). Such an approach assumes that problems are clear, dis-creet, and relatively simple and predictable, with expectations of controlling the processes that lead to problems, or ameliorating problems after they occur, with solutions that are "direct, appropriate, feasible, and effective over most relevant spatial and temporal scales" (Holling and Meffe, 1996). The initial 1972 Great Lakes Water Quality Agreement is a typical example of a technocratic approach with a relatively straightforward regulatory emphasis on point sources of visible pollution (Heathcote, 2009)—and arguably, appropriately so. The phosphorus abatement program initiated by the 1972 Agreement led directly to water quality improvement, although to a lesser extent than was expected (IJC, 1976). In fact, command and control methods can and do contribute to stable and healthy societies, and within some limits this desire to control is an undeniable collective benefit. Severe ecological, social, and economic consequences can result, however, when those same methods of control are applied to complex systems when the same predictable outcomes are expected but rarely obtained. It is the response to such surprises—the further application of control, where control is incomplete at best and perhaps fleeting—that produces the pathology of natural resource management (Holling, 1995; Holling and Meffe (1996). McLaughlin (2008) explains that

> the eventual misfortune begins innocently enough: a single element of a system is identified as valuable, almost always in economic terms, and management efforts are directed towards its steady and maximal exploitation. For a time, perhaps a very long time, the system delivers the goods to humans with regularity. That such consistency fosters a sense of relaxed certainty in people is therefore of little wonder. But nature has a bothersome habit of producing random and unanticipated events that we often find suboptimal. The pathology results when we counter those events with an intensified application of the

same techniques of command and control where our winnowing of natural variability has already diminished the system's capacity to persist. It's like throwing good money after bad.

Pathology is the branch of medicine that investigates the nature of disease—its structural and functional effects on the body that produce deviations from a healthy condition. It is essential for the treatment of disease through identification and determination of disorders and their processes that can be remedied (Hogwood and Peters, 1985). Treatment can be confounding, however, because people hold multiple and sometimes conflicting ideas about the nature of disease and desires for optimal health. People similarly differ in how they perceive threats to ecosystem productivity from human activity, and in their expectations and concern for the stress-responses of ecosystems. In turn, these various notions inform techniques of resource exploitation (Holling and Meffe, 1996), how we determine goals for ecological restoration (Regier et al., 1999), and whether we are more or less inclined to appreciate that our seemingly successful management of target resources over short periods tends to disassociate social subsystems from their ultimate dependence on environmental life supports (Folke, 2003, 2006; also Miller, 1999). Indeed, Holling and Meffe (1996) suggested that the traditional approaches of the 'less inclined' not only contribute to a loss of resilience (i.e., health) in ecological systems such as the Great Lakes, but also promote pathological traits in human systems with respect to resource management organizational behaviour and the potentially flawed policy regimes within which they are embedded.

We present empirical Great Lakes evidence of barriers to ecological revitalization associated with behavioural characteristics inherent to policy regimes generally, and to regulatory organizations in particular. We argue that the present approach to Great Lakes governance is grossly inadequate to understand and respond to diffuse, confounded and nonlinear changes occurring presently in the Great Lakes. The 2010 governmental renegotiation of the Agreement, the first since 1987, is a watershed opportunity to significantly enhance our capacity for addressing ecological and institutional threats to further progress in Great Lakes restoration (Krantzberg, 2009). Such an opportunity is vital for institutional health in the Great Lakes, as the region's governance regime has been in decline since the late 1980s, and prolonged indifference to the Agreement threatens its relevance (Botts and Muldoon, 2005). As the renegotiation proceeds into 2011, however, it is uncertain if the process and outcomes will adequately address the diminishment of institutional legitimacy. Our purpose is to illustrate how systemic management pathologies in the Great Lakes have undermined coordination and accountability, attenuated the integration of science and policy, and stymied public enthusiasm.

Background

Hogwood and Peters (1985) extended the medical concept of pathology to "understand the disorders which governments encounter in making and implementing public policy." The pathology of natural resource management implies a deviation in ecosystem health due to causes that are fundamentally institutional and social (Holling and Meffe, 1996; also Hogwood and Peters, 1985). Characteristics of offending regimes, particularly among government authorities, include dominating cultures of control and a strong resistance to new ideas and innovation—characteristics that lead to myopic rigidity and a subsequent decline in program efficacy. Holling and Meffe (1996) concluded that pathological authority that comprise the evolution of policy regimes to more adaptive behaviours must be recognized and modified. To this end, Briggs (2003) identified several symptoms exhibited by institutions suffering from the pathology of natural resource management. In order to further a diagnosis of institutional pathologies in the Great Lakes, below we repeat the symptoms identified by Briggs (2003) as subsection headings and provide select evidence of Agreement-related pathological behaviours for each.

Discussion

Institutions dominated by cultures of control will have low resilience to new challenges and, according to Briggs (2003), exhibit several identifiable characteristics of pathological management. The following six subsection headings describe six such symptoms, and the text associated with each subsection heading provides evidence to illustrate where management to restore the Great Lakes has suffered from such pathologies. These results are meant to be illuminating and not comprehensive.

They delay dealing with problems, then try quick fixes usually with a big stick.

Contested navigation rights in North America have been the subject of treaties and agreements for more than 200 years. Attempts to apportion water for hydropower led to the Boundary Waters Treaty, but it was typhoid and cholera outbreaks around the Great Lakes a century ago also motivated the inclusion of pollution and human health into the Treaty (Botts and Muldoon, 2005). Krantzberg (2008) notes that it was the conviction of the negotiators to design the IJC as a permanent, binational institution for dispute resolution rather than rely on bilateral diplomacy. Under the Treaty, the IJC was given quasi-judicial power to apply governing principles for water use and the arbitral power to resolve disputes. Additionally, the IJC is periodically requested by the federal governments to investigate specific boundary water issues

using its own board of experts in what are called 'references' (Botts and Muldoon, 2005; Findlay and Telford, 2006).

The first reference to the IJC to investigate pollution and the deterioration of water quality in the Great Lakes was made in 1912. "Pollution is a serious menace to public health," the IJC's report concluded, describing "a situation along the frontier [i.e., along the boundary through the shared waters of the Great Lakes] which is generally chaotic, everywhere perilous, and in some cases disgraceful" (IJC, 1918). Later that same year there followed a proposal for a pollution agreement with enhanced IJC powers that was not acted upon (Botts and Muldoon 2005). Another reference to the IJC focused on pollution in connecting channels was completed in the late 1940s, but again, there was no follow up to address growing problems with a comprehensive effort.

Responding to another reference in 1964 regarding deteriorating conditions in Lakes Ontario and Erie, the IJC (1970) in its report to the governments identified excessive phosphorus loadings as the main reason for accelerated eutrophication of the Lakes and the deterioration of water quality and other related consequences. Finally, the recommendations of an IJC reference report on Great Lakes pollution were addressed substantively with governmental negotiations for the initial Agreement during the period 1970-72 and dealing with water quality in the Great Lakes—60 years after the first studies were made of Great Lakes pollution and about a century following the first outbreaks of water-borne diseases from polluted water in the Great Lakes were reported (Francis and Regier 1995). Although the decades of delay were easily measured, the technocratic management of resources and its adherent "mindscape" dominant during that period were emblematic of a 'big stick' of approach that will be of diminishing utility as the Great Lakes regime continues to evolve and embrace approaches to managing open self-organizing systems with emergent features (Regier et al., 1999).

They announce and instigate new natural resource management programs repeatedly, without evaluating the effectiveness of current or previous programs.

By frequently changing programs and announcing new ones, institutions give the false impression that they are adaptive, forward looking, and solving problems (Briggs, 2003). This becomes pathological where little to no effort is made to thoroughly assess the efficacy of past and on-going programs and their coordination at the time of launching new endeavours. This turnover technique can work for a period of time, but ultimately the knowledge base and adaptive capacity of organizations and related communities become depleted, even exhausted. Botts and Muldoon (2005) summarize this pattern of pathologic behaviours in the evolution of Great Lakes governance described above:

Changes in the institutional arrangements and their functions have been made by both the governments that are the Parties and their agencies and by the IJC. The governments politicized the appointment of IJC commissioners and undermined the Commission's continuity in leadership and independence. The lead agencies substantially withdrew from the binational process envisioned in the Agreement, and undermined the public involvement that is so important for stimulating the political will of the governments. The IJC itself has reduced public participation by diminishing its efforts to disseminate public information and with changes in the format of the biennial meetings. The IJC has also allowed changes in the function of the advisory boards and diminished its own staff capabilities. The result has been loss of stature and respect for the IJC, which contributed to the reduced vigour of the Agreement processes and the reduced involvement of the Great Lakes community in the 1990s.

As we have said previously, "there has been no evaluation by the governments of the effectiveness of BEC [the Binational Executive Committee] or the IJC and its institutions" and the consequences of structural changes to Great Lakes governance has received "little if any formal inspection" (McLaughlin and Krantzberg, 2006). It is therefore concerning that similar characteristics of the possible inclusion in the Agreement of what the IJC (2009a) calls the "nearshore framework" also fits this description, particularly with respect to the history of Remedial Action Plans (RAPs). The nearshore framework is suggested by the IJC (2009a) as necessary to "better address the science, resource management and policy issues of the Great Lakes nearshore," given that the nearshore is the "vital link" between the watershed and the offshore waters (that have been the historic focus of the Agreement). The Areas of Concern (AOCs), for which RAPs were developed to remediate, are all located in tributaries, tributary mouths, connecting channels, or embayments, and hence these "existing institutional arrangements could be used or modified to better address problems in the nearshore areas" (IJC 2009a). Of note, the IJC (2009a) states that an adaptive management strategy is "the cornerstone to better addressing the nearshore...." And yet, the Parties are moving to a nearshore framework without a rigorous evaluation of what procedural elements of governance did and did not work under the RAP program. In the absence of evidence to the contrary, it is not cynical to suggest that the nearshore framework is a new name for the same program devoid of learning and understanding of federal enabling mechanisms beyond what limited and anecdotal evidence exists.

Adaptive management is a rigorous approach to learning, even across large-scale regional systems, through the deliberate treatment of policies as hypotheses and the subsequent design of management activities as experiments (Holling and Walters, 1990). Managers specifically observe how the system responds to managerial manipulations and use what is learned about such behaviour to decrease the uncertainty involved in future decisions regarding how to best understand and realize desired policy outcomes (e.g., Walters, 1986). However,

adaptive management is a widely misconceived and frequently misapplied approach to resource management (Gregory et al. 2006; Murray and Marmorek, 2004). Despite the intuitive appeal of 'learning by doing', scientists often fail to appreciate the broader array of management priorities and to recognize the need to provide information that can be directly used by decision makers; overlapping management agencies to often fail to fully and clearly define their responsibilities for implementation of adaptive management; and perhaps most significantly, implementers often demonstrate a lack of appreciation for the processes required for creating trust, shared understanding, and collective decision making among diverse stakeholders (Gregory et al., 2006; also Miller, 1999). The IJC (2009a) acknowledges these qualities and challenges in recommending that adaptive management provide the foundation for a renewed Agreement's nearshore framework, noting that "adaptive management focuses on learning and adapting through partnerships of managers, scientists and other stakeholders who learn together how to create and maintain sustainable ecosystems" and that it is "most fundamentally, an ecosystem approach to management, protection and restoration." But was this not the intention of RAPs?

RAPs were initially described as "an experiment in institutional cooperation" (Hartig et al., 1991). But the governments did not approach implementation of RAPs as an 'experimental' process to derive reliable knowledge (i.e., produce formal 'learning *while* doing' remedial action). Monitoring, for example, is a cardinal element of any systematically designed learning process (Murray and Marmorek 2004), and adaptive management is designed primarily to allow managers to learn about the complex systems being managed by monitoring the results of intentional management initiatives (Gregory et al., 2006). A decade following the creation of the RAP program, Grima (1997) noted that it was still necessary to identify the "critical factors that would enhance the success of future efforts" to restore AOCs. Further, the IJC's (2003) most recent special report on the status of AOC restoration activities stated that it was "evident that few Remedial Action Plan practitioners could estimate the degree to which the local environment was responding to remedial actions taken, partly because monitoring is insufficient to provide this information." Adaptive management is propitious where the intent is a transparent decision-oriented program (MacDonald et al., 1999), and yet the IJC (2006b) recently reported that "RAP progress reports have not been issued in recent years," and that the governments still need to "identify measurable targets, use common measures to evaluate performance and establish timelines for completion that would support a comprehensive review" of the RAP program.

Gregory et al. (2006) propose numerous questions, some that we repeat below, as criteria for judging the appropriateness of adaptive management in a variety of circumstances that have relevance for Great Lakes governance given the discussion above. Is there explicit policy guidance and leadership support for adaptive management? Will stakeholders see

adaptive management as an effective way to deal with uncertainty? Is there sufficient management flexibility and continuity to incorporate new information in revised experimental designs? Does the proposed adaptive management design involve any trade-offs that might be considered taboo by some stakeholders? Are sufficient analytical skills available to design, evaluate, and monitor adaptive management plans? These are critical questions for Great Lakes policy makers and stakeholders to address because adaptive management has become popular to promote but rarely employed in the Great Lakes (although see, for example, Hansen and Jones, 2008).

On the contrary, there is evidence that the governments demonstrate neither the capacity nor (more importantly) the inclination to conduct management with the rigour required by a legitimate adaptive management program. But our analysis is not an argument against developing a nearshore framework for the Agreement that incorporates RAPs among other initiatives. It is an indictment of policy development and redevelopment bereft of intentional reflection and analysis to learn lessons about the strengths and limitations of bureaucratic arrangements or management programs in advance of their deliberate modification or elimination. Adaptive management can help overcome the pathology of instigating new programs on the presumption that those being replaced have underperformed but in the absence of understanding why.

They instigate multiple, often incompatible plans and planning processes.

Incompatibility exacerbates the significant challenges of both collaborative management and the effective communication of science and policy. In the first instance, processes that target differing audiences can lead to incompatible objectives. The Great Lakes Fishery Commission is a catalyst for joint programs and research projects and it serves as a forum for management agencies. In some respects, so do Lakewide Management Plans (LaMPs), but because each targets a different audience, objectives on what would seem the same issue can be at odds: LaMPs set fish and wildlife population targets as a measure of Lake health, as a reflection of a restored Lake, whereas the GLFC bases its objectives, for example, on the requirements of sport fishery stakeholder groups. As a result, seemingly similar goals can lead management to seemingly opposing endpoints (e.g., stocked versus native self-reproducing populations).

In the second instance, contamination levels in local fishing areas are monitored by numerous federal, state or provincial, and regional environmental agencies, for example, in order that they can issue consumption advisories that recommend limits or avoidance of certain fish caught from certain locations. However, there is currently no accepted method to guide and compare the net risks to benefits of consuming those fish, and fish consumption advisories in

the Great Lakes vary significantly among state and provincial jurisdictions for the same species (IJC, 2000, 2004, 2009b).

More broadly, incompatible objectives are symptomatic of the inadequacy of overall restoration oversight. For example, Canada's Office of the Auditor General (OAG, 2001) examined the role and performance of the federal government in protecting the Great Lakes. Its report assessed whether the government had fulfilled its mandate, legislative responsibilities, and other Great Lakes policy commitments, whether it had applied good management practices, and whether it had established good governance structures. "Important matters are adrift," the report concluded. Funding for federal departments was "declining and unstable" and this "significantly impaired" the government's ability to achieve environmental objectives and meet Canada's international commitments on the Great Lakes. Federal priorities and policies had received inadequate resources, and "so exist only on paper" with no apparent plan for further efforts. Overall, federal actions were often short-term and unconnected to any long-term strategy, backed by limited research and monitoring, and missing basic information needed to measure the ecosystem health, understand existing and emerging stresses, and to evaluate the effectiveness of its actions. The federal role was "changing, waning, unclear," the report concluded, with federal capacity "going in the wrong direction."

The U.S. General Accounting Office similarly investigated the funding, coordination, and performance of nearly 200 American federal and state Great Lakes programs (GAO, 2003). The report found that "no overarching plan for coordinating and tying together [U.S. federal] strategies and program activities into a coherent approach" for Great Lakes restoration existed. Beyond the lack of a comprehensive plan, the report concluded that "a comprehensive assessment of restoration progress... cannot be determined with the piecemeal information currently available."

In both countries, the federal presence and commitment necessary for the success of a binational restoration agenda was reluctant on balance, even shrinking. Botts and Muldoon (2005) catalogue this trend, suggesting that "a lack of continuity" and a decline in "the vigour of the community around the Agreement" is a (somewhat unanticipated) result of a deliberate realignment of the relationship between the Parties and the IJC that has undermined the binational institutional framework that is essential to the success of the Agreement.

Most recently, the Obama Administration's campaign pledge of a Great Lakes Restoration Initiative worth $5-billion (US) over ten years has begun with $475 million (US) approved in the federal 2010 budget (Gibson, 2009; Koff, 2010). Moreover, the GLRI comes with a new senior advisory position to coordinate restoration activities involving a dozen federal agencies (Flesher, 2009) to clean up toxic sediment, restore nearshore habitat, and fight invasive species by targeting "shovel ready" projects (Koslow, 2009). The GLRI's first year financial

commitment, however welcome, pales in comparison to the estimated $20 billion (US) required to rehabilitate all U.S. AOCs in the Great Lakes (Flesher, 2009), and may not survive more short-term priorities (Egan, 2009). Months before the 2010 U.S. midterm elections, the Administration acknowledged that measurable results from those initial seeded projects would need to be swift in order to help ensure that GLRI funding would continue into the second of a proposed five years (Davis, 2010). Uncertainty for that funding is increased given the results of those elections (e.g., Boodhoo, 2010; Danitz Pache, 2010a, 2010b). Meanwhile, the Canadian federal government has been sharply criticized in that its 2009 budget did not mention the Great Lakes (Gibson, 2009), and Great Lakes restoration spending directed at the Canadian AOCs (at roughly 1% of the level of U.S. spending), has decreased relative to recent years (Environment Canada, 2010).

They have closed cultures which suppress ideas within the organization and they resist new ideas or information from outside.

All organizations have an internal knowledge base and operational mentality that defines their culture and guides their activities, particularly where past experience serves as an exemplar for future action (Miller, 1999). The maintenance of culture by controlling interests, however, creates "information flow pathologies" within organizations that better affirm current group think rather than reflect changing circumstances or possible alternative futures (Lee, 1992). Options and opinions are limited under such group cognitive constriction and dissent is suppressed with intimidation (Miller, 1999), the tactics of which become increasingly severe as the perceived threat persists (Miller, 1984). Organizations that promote conformity by discouraging information or behaviours outside the norm are highly regimented and yet brittle, becoming increasingly susceptible to new challenges (Holling and Meffe, 1996). Such resistance to novelty and innovation can create a "rigidity trap" (Holling et al., 2002), a universal tendency of bureaucracies that contributes to a general pathology of management (March, 2006; Miller, 1999).

We can suppose that the cultures of the federal governments as reflected by their departments and agencies, provides in large measure the knowledge base and mentality on which the overarching institutional approach to Great Lakes management and restoration is founded. Officials responsible for the 1987 Agreement amendments now admit that the purpose of the duplication in coordinating bodies (i.e., the creation of the BEC) was to diminish IJC oversight and allow the lead agencies to fulfil their implementation obligations by working directly together, rather than through the binational institutions provided in the Agreement. Whether intended or not, the withdrawal of the governments from the IJC framework and the

creation of an "unsatisfactory" parallel processes under the BEC has failed to provide "meaningful information" through the State of the Ecosystem Conference (SOLEC) (Botts and Muldoon, 2005; also Barr et al., 2010). Again, a principal function of the IJC under the Agreement is to assess implementation progress and report those results to the governments and the general public. Because the IJC relies primarily on its advisory boards for the information needed to fulfill this function (which they collected with the cooperation of the governments), the capacity of the IJC was significantly diminished by the restructuring of Great Lakes governance that removed much of the IJCs responsibility and independence that had been the catalyst for policy innovations in the past (Botts and Muldoon, 2005). The Great Lakes regime therefore is not unlike most others that "make only feeble efforts to organize and integrate the enormous store of information" generated by their activities and programs (Miller, 1999).

Earlier we described the extent to which evaluative activities such as adaptive management, in particular, are being proposed for inclusion in governmental Great Lakes programs. Such ideas when implemented adequately disturb the common pervasiveness of fear and defensiveness of management organizations (Miller, 1999). Adaptive management is useful where it reflects the paradoxical need for stability and change in organizations, and where dissent from people, ideas, or information is considered a constructive element in organizational processes. The previous remodelling of the Agreement led to an existing information flow pathology that, unless examined for its underlying human dimensions, casts significant doubt on the efficacy of any innovative learning tool proposed by the governments during the current Agreement renegotiation.

They shed extension officers[5], often in favour of regulatory officers, and then expect scientists and planners to take on the extension role.

Briggs (2003) suggests that in absence of strong leadership and coordination, non-governmental organizations and other elements of civil society are required to assume technical roles and monitor water quality, for example, often without training or financial support, and subsequently with significant frustration. In the Great Lakes, this trait has emerged with the precipitous disengagement of governmental agencies from the IJC processes that at one time were touchstones for the engagement of the broad Great Lakes community. This disengagement was evident in the experience with Great Lakes Remedial Actions Plans. RAPs were established by Annex 2 following the 1987 Agreement renewal to provide principles and proce-

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[5] These are intermediaries between research or any other source of new information and resource users that might use the products of research. They operate as knowledge brokers, facilitators, and communicators to help resource users make decisions and ensure that appropriate knowledge is utilized.

dures for the governments to use to restore beneficial uses in dozens of Areas of Concern (the most polluted and otherwise degraded geographic areas in the region). In Canada, at least, this disengagement led to a rapid turnover of RAP coordinators, a lack of attention to community capacity building, and the abandonment of entire AOCs due to lack of funds (Krantzberg, pers. obs.).

Natural resource institutions with the pathology fail to develop effective incentive schemes for conservation on private land.

The Agreement makes minimal mention of private property, and makes no reference to incentive-based conservation. Within the Great Lakes basin, however, there are initiatives such as Ontario's recent Norfolk (County) Alternative Land Use Services (ALUS) pilot project that are encouraging restorative land use practices that maintain natural capital. In a short period, the farmer-led ALUS project has helped return nearly 500 acres of marginal farm land to native habitat in partnership with stakeholders from the agricultural community (Norfolk ALUS, 2010).

There is context for new programs such as ALUS that bears recalling for our purposes. A new Ontario provincial government in 1995 terminated numerous participatory management programs with direct stakeholder involvement and incentive-based conservation measures, including farm plans to better manage animal waste, community fishery and wildlife improvement plans to enhance riparian habitats, and funding that helped municipalities conduct home energy and water audits to encourage householder conservation. The political reasons for such action may have been arguably valid, but in the absence of evidence to suggest that the programs were not achieving their intended environmental and social objectives (and no such evaluation was conducted; Krantzberg, pers. obs.), such action is pathological.

It is also instructive to consider the impact of disincentives on program goal attainment. As discussed earlier, changes in the Agreement in 1987 diminished the IJC's mandate over time and led to a significant reduction in the seniority of members of its Great Lakes advisory boards; consequently, the IJC's authority to evaluate the effectiveness of the Parties' programs under the Agreement was also diminished (Botts and Muldoon, 2005). What might be the implications of this wane in the IJC's stature for the implementation of adaptive management, among other potential policy innovations? Gregory et al. (2006) warn that the perceived risks of failure for policy that explicitly promotes experimental approaches—risks both to resources and to institutions—present significant disincentives for governments to provide adequate program resources over the temporal scales required for any adaptive management program to be properly conducted. The decline in the IJC's ability to evaluate programs and the ineffectiveness of SOLEC indicators suggest that neither the IJC nor the Parties are well positioned to sufficiently

undertake initiatives as demanding as adaptive management, for example, without incurring pathological outcomes.

Finally, Canada's National Round Table on the Environment and the Economy is preparing to launch a large-scale study in 2011 of incentive programs for water protection across multiple resource sectors. The renewal of the Agreement might consider the application of such inquiry, particularly given the current attraction of adaptive management within the Great Lakes regime, as results of incentive-based conservation methods are a necessary component of adaptive and participatory management designed to learn (Folke et al., 2005; Villard and Nudds, 2010).

Conclusions

Beyond determining appropriate indicators with which to measure health, the ecosystem health concept is a powerful metaphor for structuring an evolving postmodern appreciation of the complexity of linked systems of people and nature (Ross et al., 1997; Holling, 2003). In this view, social-ecological systems are dynamic, governed by positive and negative feedback and inherent uncertainty that precludes entirely predictable system behaviours. In coming to such realities "there is no correct perspective" (Kay and Regier, 2000), although such circumstances naturally create new opportunities to integrate the social, natural, and health sciences (Rapport et al., 1998).

The evidence that we have presented of pathological behaviours in the management of the Great Lakes illustrates several limitations in how we conceptualize the dynamics of social-ecological systems, and how we formulate approaches to policy and problem-solving to cope effectively with those dynamics. Such limitations are an underlying cause of the pathology of natural resource management, where a loss of resilience in a system occurs when the variety of its attributes or options are narrowed or otherwise restricted—species diversity in an ecological system, for example, or innovative ideas in a social system. Limitations are also a result of the pathology we have described, in that management often tends towards a technical rationality that narrows or otherwise restricts policy and action to the repetition of familiar yet largely unsuccessful increments (Caldwell, 1995; Miller, 1999). In politics, however, such increments are usually more acceptable and less hazardous than initiatives to find deeply effective solutions that require systemic change.

It is instructive that the World Health Organization defines health not simply as the mere absence of disease, but as a state of complete physical, mental, and social well-being (WHO, 1948). The definition embodies the dichotomy of traditional, linear approaches to health (e.g., conclusions limited to presence/absence) and comprehensive, systemic approaches (that consider but also integrate indicators such as presence/absence within a more sophisticated

framework of information feedbacks). The definition also underscores the principal motivation for discovering institutional problem-solving remedies for complex and uncertain policy problems: the prevention of perturbations (to ecological and social systems) is often a major goal of management (not surprisingly), but often overlooked is the need to reduce the risk of undesirable system shifts by addressing the more fundamental changes that affect resilience, rather than merely controlling disturbance (Scheffer et al., 2001). With respect to governance, such fundamental changes will involve being attuned to much more than the mere presence/ absence of aspects of modern policy making that have come to be expected, such as public participation or stakeholder engagement. Governance regimes must be attuned to the fundamental psychosocial needs and processes of governance that create and sustain sufficiently meaningful social processes in policy, and subsequently resilience in social systems. Learning processes and stakeholder incentives will both be undermined by the pathological management as documented above: non-existent program evaluation, significant program incompatibility, significant lack of coordination among programs, authorities that establish then abandon public participatory initiatives, and an inappropriate choice of policy mechanisms or an inadequate level of support for an appropriate mechanism (either of which creates disincentives for stakeholders).

Learning is an element of resilience and therefore central to avoiding pathologies in management; but learning (individually or institutionally) can be threatening and very difficult. Furthermore, learning is not simply 'finding the answer' but necessarily involves a continuous process of interpretation, evaluation, and reformulation (Michael, 1995), sometimes even of the question itself. Acquiring knowledge involves not simply knowing what to learn, but how to learn. Argyris and Schön (1978) distinguished double-loop from single-loop learning as going beyond a simple detection-and-correction approach to incorporate a second loop that questions the assumptions, policies, practices, priorities, and system dynamics involved in sustaining the problem (and possibly hindering its solution). Tactical change to improve immediate outcomes requires only single-loop learning, whereas systematic change to either prevent a problem or to embed a solution into a system involves double-loop learning (Patton, 2010). For example, the Agreement calls for "the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem" to be *maintained*, not simply restored to a single end point [our emphasis]. What is to be maintained? By whom? How? To what degree? And how will we know when our assumptions and the evidence for what is being maintained are no longer sufficient?

We do not want to leave the impression that all is broken in the Great Lakes regime. The RAP program, for example, is not without its limited successes, and researchers have made great gains in understanding the natural science of the Great Lakes. But as we have said previously, the social science for Great Lakes sustainability must obtain equal priority if

institutional learning is to be operationalized (McLaughlin and Krantzberg, 2006). Regardless of extent of Great Lakes institutional reforms undertaken related to a renewed Agreement or otherwise, processes to ensure the maintenance of a rehabilitated Great Lakes will require ongoing decisions where risk is associated with opportunity. We must plan to learn from our successes and failures.

But neither do we want to leave the impression that the variety of evidence we present is a random assortment of unrelated problems. These pathological behaviours underscore the need for a revitalized "regional consciousness" to overcome our "preoccupation with what is, and to focus instead on what could be" (Donahue, 1988). The combined evidence speaks to the need for traditional approaches to be supplanted with an integrative 'learning while doing' ethos regarding complex problems, uncertain science, and participatory governance. It has been observed that learning is a stepwise process, and that double-loop institutional learning changes the policy frame of reference and calls guiding assumptions into question (Pahl-Wostl, 2009). In this context, advances in research on resilience and the emergence of a "new ecology" (Scoones, 1999; also Folke, 2006) challenge traditional, static views in the natural and social sciences. A renewed Agreement must therefore foster the adaptive capacity of the Great Lakes regime by equipping it with the rigour to generate reliable knowledge and the flexibility to learn (i.e., incorporate new knowledge into practice) in order to sustain the social and ecological relationships critical for resilience of the Great Lakes system. We believe that there are pragmatic methodologies to begin to make this transition to adaptive governance in the Great Lakes regime where opportunities are carefully selected and appropriate attention is given to efficacious implementation.

The institutionalization of the ecosystem approach in the Great Lakes is a policy goal, perhaps the Agreement's most ambitious and comprehensive. Essential to achieving this goal is a new and more expansive "mindscape" necessary to "transcend" traditional psychosocial constraints on realizing its character and potential (Regier et al., 1999; also Miller, 1999). Interestingly, the significance of this new consciousness was anticipated by the IJC's Great Lakes Research (now Science) Advisory Board in 1978, with its observation that implementation of the ecosystem approach will demand a "conceptual transformation" involving a new "mindset" (RAB, 1978). We could not agree more, and hope that the appraisal presented here will further this challenging task.

Acknowledgements

Literature Cited

Argyris C, Schön DA. 1978. Organizational Learning: A Theory of Action Perspective. Addison-Wesley.

Bails J, Beeton A, Bulkley J, DePhilip M, Gannon J, Murray M, Regier H, Scavia D. 2005. Prescription for Great Lakes Ecosystem Protection and Restoration: Avoiding the Tipping Point of Irreversible Changes. Wege Foundation and Joyce Foundation. Accessed 29 Jan 2011 at http://nsgl.gso.uri.edu/michu/michui05009.pdf.

Barr J, Hall TJ, Harris HJ, Krantzberg G, Sowa S. 2010. Review Report of the SOLEC Independent Expert Panel. Presented to Environment Canada and the U.S. Environmental Protection Agency. Accessed 30 Nov 2010 at http://msep.eng.mcmaster.ca/epp/publications.html.

Bell A. 1994. Non-human nature and the ecosystem approach: the limits of anthropocentrism in Great Lakes management. Alternatives, 20.3: 20-5.

Berkes F, Colding J, Folke C, editors. 2003. Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press.

Berkes F, Folke C, Colding J. 1998. Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge University Press.

Berkes F. 2002. Cross-scale institutional linkages: perspectives from the bottom up. In: The Drama of the Commons. Ostrom E, Dietz T, Dolsak N, Stern PC, Stonich S, Weber EU, editors. pp. 293-321. National Academies Press.

Boodhoo N. 2010. Changing gears: what does Republican control mean for the Great Lakes? Accessed 4 Nov 2010 at http://www.wcpn.org/WCPN/news/32785.

Botts L, Muldoon P. 2005. Evolution of the Great Lakes Water Quality Agreement. Michigan State University Press.

Briggs S. 2003. Command and control in natural resource management: revisiting Holling and Meffe. Ecological Management and Restoration, 4: 161-162.

Caldwell L. 1995. Environment as a Focus for Public Policy. Texas A&M University Press.

Carpenter SR, Gunderson LH. 2001. Coping with collapse: ecological and social dynamics in ecosystem management. Bioscience, 51: 451-457.

Carpenter SR. 2002. Ecological futures: building an ecology of the long now. Ecology, 83: 2069-2083.

Clapcott JE, Young RG, Goodwin EO, Leathwick JR. 2010. Exploring the response of functional indicators of stream health to land-use gradients. Freshwater Biology, 55: 2181-2199.

Danitz Pache T. 2010. Call the Senate in Support of GLEPA. Healing Our Waters – Great Lakes Coalition. Accessed 23 Nov 2010 at http://www.healthylakes.org.

Danitz Pache T. 2010. Great Lakes Programs Need Champions in New Congress. Healing Our Waters – Great Lakes Coalition. Accessed 23 Nov 2010 at http://www.healthylakes.org.

Davis C. 2010 Using science to guide Great Lakes restoration. Keynote Address to the International Association for Great Lakes Research conference. May 20. Toronto, Canada.

Dobiesz NE, Hecky RE, Johnson TB, Sarvala J, Dettmers JM, Lehtiniemi M, Rudstam LG, Madenjian CP, Witte F. 2010. Metrics of ecosystem status for large aquatic systems – A global comparison. Journal of Great Lakes Research, 36: 123-138.

Donahue MJ. 1988. Institutional arrangements for Great Lakes management. In: Perspectives on Ecosystem Management for the Great Lakes: A Reader. Caldwell LK, editor. pp. 115-139. State University of New York Press.

Egan D. 2009. Great Lakes aid isn't a cure-all. Milwaukee Journal Sentinel; Oct 25. Accessed 25 Jan 2010 at http://www.jsonline.com/news/wisconsin/65957972.html.

Environment Canada. 2010. Great Lakes Action Plan. Accessed 17 Dec 2010 at http://www.ec.gc.ca/grandslacs-greatlakes/default.asp?lang=En&n=DF30B51A-1.

Findlay R, Telford P. 2006. The International Joint Commission and the Great Lakes Water Quality Agreement: Lessons for Canada-United States Regulatory Co-Operation. Government of Canada, Policy Research Initiative, Working Paper Series 023.

Flesher J. 2010. EPA appoints czar for Great Lakes clean up. USA Today. Accessed 5 Jun 2010 at http://www.usatoday.com/tech/science/environment/2009-06-05-great-lakes_N.htm.

Foley MM, Halpern BS, Micheli F, Armsby MH, Caldwell MR, Crain CM, Prahler E, Rohr N, Sivas D, Beck MW, Carr MH, Crowder LB, Duffy JE, Hacker SD, McLeod KL, Palumbi SR, Peterson CH, Regan HM, Ruckelshaus MH, Sandifer PA, Steneck RS. 2010. Guiding ecological principles for marine spatial planning. Marine Policy, 34: 955-966.

Folke C. 2003. Freshwater for resilience: a shift in thinking. Philosophical Transactions of the Royal Society B: Biological Sciences, 358: 2027-2036.

Folke C. 2006. Resilience: the emergence of a perspective for social–ecological systems analyses. Global Environmental Change, 16: 253-267.

Folke C, Hahn T, Olsson P, Norberg J. 2005. Adaptive governance of social-ecological systems. Annual Review of Environment and Resources, 30: 441-473.

Francis GR, Regier HA. 1995. Barriers and bridges to the restoration of the Great Lakes Basin ecosystem. In: Barriers and Bridges to the Renewal of Ecosystems and Institutions. Gunderson LH, Holling CS, Light SS, editors. pp. 239-91. Columbia University Press.

GAO [United States General Accounting Office]. 2003. Great Lakes: an overall strategy and indicators for measuring progress are needed to better achieve restoration goals. Report GAO-03-515 to Congressional Requesters.

Gibson B. 2009. Obama budget shows Great Lakes promise. Accessed 25 Jan 2010 at http://www.glu.org/news/2009/07/obama-budget-shows-great-lakes-promise

Gregory R, Ohlson D, Arvai J. 2006. Deconstructing adaptive management: criteria for applications to environmental management. Ecological Applications, 16: 2411-2425.

Grima APL. 1997. Ten years of RAPs: reflections and suggestions. Journal of Great Lakes Research, 23: 232-3.

Hansen GJA, Jones ML. 2008. A rapid assessment approach to prioritizing streams for control of Great Lakes sea lampreys (*Petromyzon marinus*): a case study in adaptive management. Canadian Journal of Fisheries and Aquatic Sciences, 65: 2471-84.

Hartig JH, Lovett-Doust L, Zarull MA, Leppard S, New LA, Skavroneck S, Eder T, Coape-Arnold T, Daniel G. 1991. Overcoming obstacles in Great Lakes remedial actions plans. International Environmental Affairs, 3: 91-107.

Hartig JH, Zarull MA, Heidtke TM, Shah H. 1998. Implementing ecosystem-based management: lessons from the Great Lakes. Journal of Environmental Planning and Management, 41: 45-75.

Hartig JH, Zarull MA, Law NL. 1998. An ecosystem approach to Great Lakes management: practical steps. Journal of Great Lakes Research, 24: 739-50.

Heathcote IW. 2009. Integrated Watershed Management: Principles and Practice. Second edition. Wiley.

Hogwood BW, Peters BG. 1985. The Pathology of Public Policy. Oxford University Press.

Holling CS. 2003. Foreword: the backloop to sustainability. In: Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Berkes F, Colding J, Folke C, editors. pp. xv-xxi. Cambridge University Press.

Holling CS. 1973. Resilience and stability of ecological systems. Annual Review of Ecology, Evolution, and Systematics, 4: 1-23.

Holling CS. 1986. Resilience of ecosystems: local surprise and global change. In: Sustainable Development and the Biosphere. Clark WC, Munn RE, editors. pp. 292-317. Cambridge University Press.

Holling CS. 1995. What barriers? What bridges? In: Barriers and Bridges to the Renewal of Ecosystems and Institutions. Gunderson LH, Holling CS, Light SS, editors. pp. 3-34. Columbia University Press.

Holling CS, Gunderson LH, Peterson GD. 2002. Sustainability and panarchies. In: Panarchy: Understanding Transformations in Human and Natural Systems. Gunderson LH, Holling CS, editors. pp. 63-102. Island Press.

Holling CS, Meffe G. 1996. Command and control and the pathology of natural resource management. Conservation Biology, 10: 328-37.

Holling CS, Walters CJ. 1990. Large-scale management experiments and learning by doing. Ecology, 71: 2060-2068.

IJC [International Joint Commission]. 1918. Final Report on Boundary Waters.

IJC [International Joint Commission]. 1970. Pollution of Lake Erie, Lake Ontario, and the International Sections of the St. Lawrence River.

IJC [International Joint Commission]. 1976. Fifth Annual Report.

IJC [International Joint Commission]. 2000. Tenth Biennial Report.

IJC [International Joint Commission]. 2003. Status of Restoration Activities in Great Lakes Areas of Concern: A Special Report.

IJC [International Joint Commission]. 2004. Great Lakes Fish Consumption Advisories: The Public Health Benefits and Risks. Discussion paper prepared by the Health Professionals Task Force.

IJC [International Joint Commission]. 2006a. Advice to Governments on their Review of the Great Lakes Water Quality Agreement: A Special Report To The Governments of Canada and the United States.

IJC [International Joint Commission]. 2006b. Thirteenth Biennial Report.

IJC [International Joint Commission]. 2009a. Work Group Report on Nearshore Framework.

IJC [International Joint Commission]. 2009b. Work Group Report on Risks and Benefits of Great Lakes Fish Consumption.

Kay J, Regier H. 2000. Uncertainty, complexity, and ecological integrity: insights from an ecosystem approach. In: Implementing Ecological Integrity: Restoring Regional and Global Environmental and Human Health. Crabbé P, Holland A, Ryszkowski L, Westra L, editors. pp. 121-56. Kluwer, NATO Science Series, Environmental Security.

Koff S. 2010. Obama budget would provide $300 million more for Great Lakes. Cleveland Plain Dealer. Accessed 18 Dec 2010 at http://www.cleveland.com.

Koslow M. 2009. Meetings detail restoration spending plan. Accessed 25 Jan 2010 at http://www.glu.org/news/2009/09/meetings-detail-restoration-spending-plan

Krantzberg G. 2008. The Great Lakes' future at a cross road. Environmentalist, 28: 301-305.

Krantzberg G. 2009. Renegotiating the Great Lakes Water Quality Agreement: the process for a sustainable outcome. Sustainability, 1: 254-267.

Krantzberg G, Manno J, De Boer C. 2007. Great Lakes St. Lawrence River Governance: Report on the Expert Workshop. Prepared for the Joyce Foundation. Accessed 30 Apr 2010 at http://msep.mcmaster.ca/epp/publications.html

Krantzberg G, McLaughlin C, Manno J, De Boer C. 2008. Great Lakes Governance: Future Models Present Solutions. Prepared for the Joyce Foundation. Accessed 30 Apr 2010 at http://msep.mcmaster.ca/epp/publications.html

Lee R. 1992. Ecologically effective social organization as a requirement for sustaining watershed ecosystems. In: Watershed Management: Balancing Sustainability and Environmental Change. Naiman R, editor. pp. 73-89. Springer-Verlag.

Leopold A. 1941. Wilderness as a land laboratory. The Living Wilderness, July: 3.

MacDonagh-Dumler J. 2009. Policy innovation for Great Lakes ecosystem management. Journal of Great Lakes Research, 35: 477-481.

MacDonald GB, Fraser J, Gray P. 1999. Adaptive management forum: linking management and science to achieve ecological sustainability. Proceedings of the 1998 Provincial Science Forum,

Dorset, Ontario. Science Development and Transfer Branch, Ontario Ministry of Natural Re-
sources.

March JG. 2006. Rationality, foolishness, and adaptive intelligence. Strategic Management
Journal, 27: 201-214.

Marentette JR, Gooderham KL, McMaster ME, Ng T, Parrott JL, Wilson JY, Wood CM, Balshine S.
2010. Signatures of contamination in invasive round gobies (*Neogobius melanostomus*): A
double strike for ecosystem health? Ecotoxicology and Environmental Safety, 73: 1755-1764.

McLaughlin C. 2008. Thinking like an ecosystem. Alternatives Journal, 34.4: 33-36.

McLaughlin C, Krantzberg G. 2006. Toward a 'better understanding' of the Great Lakes Basin
Ecosystem. Journal of Great Lakes Research, 32: 197-199.

Michael DN. 1995. Barriers and bridges to learning in a turbulent human ecology. In: Barriers
and Bridges to the Renewal of Ecosystems and Institutions. Gunderson LH, Holling CS, Light SS,
editors. pp. 461-485. Columbia University Press.

Miller A. 1984. Professional dissent and environmental management. The Environmentalist, 4:
143-152.

Miller A. 1999. Environmental problem solving: psychosocial barriers to adaptive change.
Springer.

Murray C, Marmorek DR. 2004. Adaptive management: a spoonful of rigour helps the uncer-
tainty go down. Proceedings of the 16th Annual Society for Ecological Restoration Conference,
Victoria BC, Aug 24-26. Accessed 11 Mar 2010 at
http://www.essa.com/publications/index.html.

Norfolk ALUS. 2010. Homepage. Accessed 6 Jan 2011 at http://www.norfolkalus.com.

OAG [Office of the Auditor General of Canada]. 2001. A legacy worth protecting: charting a
sustainable course in the Great Lakes and St. Lawrence River basin, Chapter 1 of the Report of
the Commissioner of the Environment and Sustainable Development. Public Works and
Government Services Canada.

Olsson P, Gunderson LH, Carpenter SR, Ryan P, Lebel L, Folke C, Holling CS. 2006. Shooting the
rapids: navigating transitions to adaptive governance of social-ecological systems. Ecology and
Society, 11.1: art18.

Paetzold A, Warren PH, Maltby LL. 2010. A framework for assessing ecological quality based on
ecosystem services. Ecological Complexity, 7: 273-281.

Patton MQ. 2010. Developmental Evaluation: Applying Complexity Concepts to Enhance Innova-
tion and use. The Guilford Press.

RAB [Great Lakes Research Advisory Board]. 1978. The ecosystem approach: scope and implica-
tions of an ecosystem approach to transboundary problems in the Great Lakes basin. Special
report to the International Joint Commission.

Rapport DJ, Costanza R, McMichael AJ. 1998. Assessing ecosystem health. Trends in Ecology and
Evolution, 13: 397-420.

Regier HA, Grima AP, Francis GR, Lerner S, Hamilton AL. 1990. Integrity and surprise in the Great Lakes basin ecosystem: implications for policy. In: An Ecosystem Approach to the Integrity of the Great Lakes in Turbulent Times. Edwards CJ, Regier HA, editors. pp. 17-35. Great Lakes Fishery Commission Special Publication 90-4.

Regier HA, Baskerville GL. 1986. Sustainable redevelopment of regional ecosystems degraded by exploitive development. In: Sustainable Development of the Biosphere. Clark WC, Munn RE, editors. pp. 75-103. Cambridge University Press.

Regier HA, Jones ML, Addis J, Donahue M. 1999. Great Lakes–St. Lawrence River basin assessments. In: Bioregional Assessments: Science at the Crossroads of Management and Policy. Johnson KN, Swanson FJ, Herring M, Greene S, editors. pp. 133-165. Island Press.

Ross N, Eyles J, Cole D, Iannantuono A. 1997. The ecosystem health metaphor in science and policy. The Canadian Geographer, 41: 114-127.

Scheffer M, Carpenter S, Foley JA, Folke C, Walker B. 2001. Catastrophic shifts in ecosystems. Nature, 413: 591-596.

Scoones I. 1999. New ecology and the social sciences: what prospects for a fruitful engagement? Annual Review of Anthropology, 28: 479-507.

Steedman, R. J., and H. A. Regier. 1987. Ecosystem science for the Great lakes: perspectives on degradative and rehabilitative transformations. Canadian Journal of Fisheries and Aquatic Sciences, 44.s2: 95-103.

Villard M-A, Nudds TD. 2010. Clubs, carrots, and conservation. Avian Conservation and Ecology, 5.2: art14.

Walters CJ. 1986. Adaptive management of renewable resources. MacMillan.

Westley F. 1995. Governing design: the management of social systems and ecosystems management. In: Gunderson LH, Holling CS, Light SS, editors. Barriers and Bridges to the Renewal of Ecosystems and Institutions. pp. 391-427. Columbia University Press.

WHO [World Health Organization]. 1948. Constitution of the World Health Organization.

Young, OR. 2008. Institutions and environmental change: the scientific legacy of a decade of IDGEC research. In: Institutions and Environmental Change: Principal Findings, Applications, and Research Frontiers. Young OR, King LA, Schroeder H, editors. pp. 3-45. MIT Press.

CHAPTER FOUR

INNOVATIONS IN DECISION MAKING[6]

A philosophic reconstruction which should relieve men of hav-
ing to choose between an impoverished and truncated experi-
ence on one hand and an artificial and impotent reason on the
other would relieve human effort from the heaviest intellectual
burden it has to carry.

— John Dewey, 1920
Reconstruction in Philosophy

Introduction

Deficiencies in how we conceptualize the complexity of collaborative social-ecological restora-
tion and the barriers to how we reform policy to cope and learn effectively in the face of uncer-
tainty are 'intellectual burdens' on Great Lakes governance. Relieving these burdens will cer-
tainly require a continued focus on the content of science and policy. But my focus is not on the
what of our understanding, but on the *how*. Substantive research into the ecological knowledge
needed for Great Lakes restoration fills journal pages and conference agendas. Yet despite that
increased understanding, "there is widespread agreement that the Great Lakes presently are
exhibiting symptoms of extreme stress from a combination of sources that include toxic con-
taminants, invasive species, nutrient loading, shoreline and upland land use changes, and hydro-
logic modifications," and that a "failure to understand the ecosystem-level disruptions caused
by the combination of multiple stresses have led to the false assumption that the Great Lakes
ecosystem is healthy and resilient" (Bails et al., 2005). In such circumstances, the content of re-
search is 'impoverished and truncated' unless matched to science-policy processes that are
more closely attuned to the properties of complex Great Lakes social-ecological systems and ca-
pable of making use of that research content to greatest effect.

The processes of management and decision making involved in Great Lakes restoration
are at once political, bureaucratic, scientific, and social. However, these processes now occur on
a scale of complexity that has outgrown the capacity of traditional management of segregated
resource uses and narrow agency mandates (Scholz and Stiftel, 2005). As such, new institutional

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[6] McLaughlin C. *In press*. Innovations in decision making. In: Great Lakes, Great Responsibilities: Lessons in
Participatory Governance. Grover VI, Krantzberg G, editors. Science Publishers, Edenbridge Ltd.

models are needed that are better able to accommodate emerging conflicts and complexity more effectively. My main contention is that such models must become adaptive to better reconcile the complexity of competing priorities and their underlying uncertainties if governance is to remain effective.

An adaptive governance model is one designed to resolve collective action problems that occur between different types of resource users in ways that resolve conflicts and lead to sustainable use of natural systems (Scholz and Stiftel, 2005). Such models make use of techniques to facilitate a broad participation in problem definition and decision making, and deal with uncertainties about both the natural systems being managed and the human organizations themselves. Dewey (1920) said that reason is not "something laid from above upon experience," that it is "employed through inventions in a thousand ways to expand and enrich experience." To that end, the focus of this chapter is on two such inventions, adaptive management and decision analysis, proposed to have potential to 'expand and enrich' adaptive Great Lakes governance. My purpose is to clarify the principles and fundamental character of these two techniques as a means to developing an institutional framework to help structure participatory decision making and adaptive governance in the Great Lakes that more directly links science to policy and management activity to program outcomes.

Governance

Critiques of current shortcomings in Great Lakes governance have come from academia (e.g., Manno and Krantzberg, 2008; Krantzberg, 2009; MacDonagh-Dumler, 2009), civil society (e.g., Botts and Muldoon, 2005; Benevides et al., 2007; Jackson and Sloan, 2008), a combination of both (e.g., Johns et al., 2005; Barr et al., 2010), and from government authorities (OAG, 2001; GAO, 2003; ARC, 2007). Commonalities among proposed remedies with relevance for this discussion include stronger accountability, greater flexibility, and public engagement that is sustained and more meaningful. Each of these elements demands that we more effectively address and incorporate the diversity of views and information now required of evolving pluralist governance models. More specifically, Manno and Krantzberg (2008) stipulate that "governance for sustainability" includes active public participation, integrated management, multi-jurisdictional collaboration, and a shared sense of responsibility. They suggest that this mix of ingredients was recognized at the outset of the regime formed around the Agreement four decades ago, and yet still a decline in the effectiveness of governance in the Great Lakes has resulted. Sources of institutional stress leading to that decline include ideological change, scale mismatches of problem and solution, and inadequacies in funding, monitoring, and program evaluation. Further, recent analyses have demonstrated significant deficits in Agreement-related implementation (i.e., numerous unmet policy objectives), with related underlying problems including non-existent pro-

gram evaluation, program incompatibility, lack of coordination among programs, authorities that establish and then abandon public participatory initiatives, and disincentives from the inappropriate choice of policy mechanisms or inadequate level of support for appropriate mechanisms (McLaughlin and Krantzberg, unpublished manuscript).

The linkages between science, policy, and management have become increasingly complex in recent decades (or at least our perception of those linkages has sharpened). A major reason for that complexity is the emergence of 'boundary organizations' and other increasingly nuanced arrangements that orchestrate activities in the worlds of science and policy and that mediate complex mixtures of discourse and subjectivity (Miller, 2001). In the Great Lakes, these arrangements include a long-standing and high-functioning non-governmental sector, and innovations in policy ranging from an ecosystem approach institutionalizing the people-in-nature view, to dozens of local Remedial Action Plans (RAPs) in the most degraded locations that involved diverse stakeholders. But even the Agreement's most laudable features are failing: a lack of careful definition in the application of the ecosystem approach under the Agreement has seen the concept misused (Manno and Krantzberg, 2008). According to the International Joint Commission (IJC, 2003b), "key challenges" remaining for the RAP program are securing the resources to implement the plans, identifying accountability and responsibility, defining restoration targets where they do not exist, setting priorities, and monitoring recovery—essentially the entire program.

Great Lakes governance must embrace opportunities to invigorate the processes of management and develop new frames of reference for treating uncertainty and engaging with people. Such processes must complement traditional decision making (Wondolleck and Lewis, 2000), but at the same time enhance those traditions through reciprocally responsible action (Westley, 1995; Regier et al., 1999). A key to such a renewal of governance is learning. Later in this chapter I discuss a specific type of learning related to uncertainty that is accomplished by adaptive management and decision analysis, but for now the focus is more broadly on policy learning as an outcome of systems thinking. Policy learning provokes "a relatively enduring alteration of thought or behavioural intentions" that are related to (and perhaps revise) "the precepts of a policy core belief system" (Sabatier, 1993). Figure 1 is a model of this idea of policy learning as it could occur in a complex problem environment. The process illustrates where fundamental changes in governance could both foster and reflect a significant new conceptualization of social-ecological complexity and new approaches to cope and learn effectively in the face of uncertainty. Figure 1 illustrates that thinking about the problem situation as one system has the potential to more broadly consider the elements and issues that define it, and that this would also stimulate a more sophisticated portrayal the behaviour of those elements, particularly where relationships are evolving. Westley (1995) suggests that this is the essence of

FIGURE 1. Three phases in addressing a problem situation with systems thinking (adapted from text in Waltner-Toews et al. 2008). The application of a systems thinking perspective to a problem situation involves three phases. To frame the situation is to describe or map elements and issues that define the situation. A description of the dynamics of a situation portrays the behaviour of those elements, particularly where relationships evolve. And synthesizing understanding from the first two phases can allow for both resolution and new perspectives and questions. The direction of the darker-shaded arrows in the problem situation indicates the flow of phases one through three. The feedback created by a new understanding and possible re-examination is indicated by the lighter-shaded arrows in the problem situation.
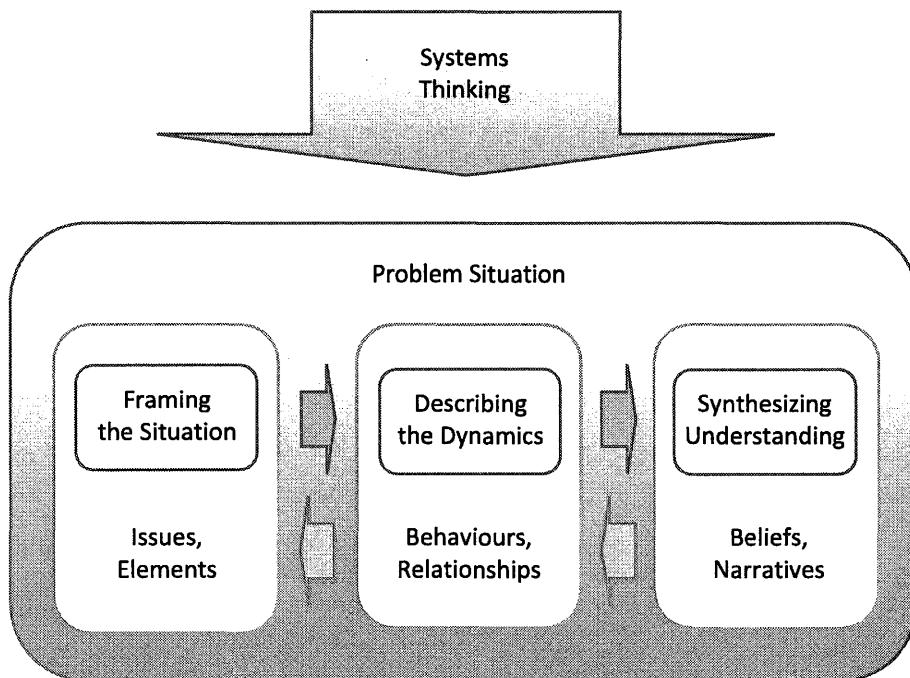
management itself, to synthesize a diversity of old knowledge and form new perspectives, and that done well, this is also the essence of leadership. The cycle continues in that the reformation of perspectives, behaviours, and relationships leads us to reconsider the elements and issues that we use to possibly redefine the problem situation.

Decision Making

A primary reason for our traditional misconceptions of social-ecological processes and behaviours is our tendency to characterize them simplistically as linear and straightforward (Holling, 1995). But where complex processes such as *deciding* may give the impression of a singular act, decisions usually result from an ongoing determination involving priorities and judgments in a stream of new and usually unpredictable information. This is true for both individual and collective decision making processes (Beratan, 2007). This section briefly considers individuals in a sketch of decision making, and makes a few observations about people and their ability to influence collective decisions.

Individual Decisions

Cognitive processes determine how we absorb information, recognize problems, and imagine solutions. Beratan (2007) explains that the human mind is thought to have a dual process of reasoning where a rapid nonconscious or preconscious mode is accessed effortlessly to contextualize the present at any given moment. Such access is automatic and comprises the vast majority of what our brains are doing continuously. Processing in this nonconscious mode is based on an individual's background beliefs and learning history. By default, we base decisions on the assumption that the result in a given situation will be very similar to the results of similar decisions in situations similar to what we have encountered in the past. But there is a second, parallel mode of conscious thought that is effortful and comprises as little as two percent of brain activity (Beratan, 2007). We rely on this mode to deal with novelty or to strategize beyond what is routine, but accessing this mode requires motivation and cognitive capacity. Our nonconscious mental mode processes quickly and efficiently, but for that we sacrifice flexibility and creativity. Beratan (2007) describes the human mind integrates new information gained from conscious processing into our experiential knowledge, and thus such learning then becomes available for fast future use by the nonconscious mode.

Beyond the architecture of the mind, people display a "bounded rationality" strategy to make decisions that are reasonable given the limited and imperfect quality of the information usually available (Simon, 1972). We are not rational optimizers, but rather we make "satisficing" decisions where we attempt to *satisfy* our needs by accounting *sufficiently* for whatever infor-

mation we can acquire (Simon, 1957). The idea of satisficing is captured by the 80:20 rule, which states that endless detail is most often not necessary and that you can generally achieve 80 percent of a desired output for 20 percent of the effort. This concept is applicable for management, whereby the top few highest ranked priorities are selected and managers invest the initial 20 percent of effort needed to solve a problem completely. The hope is that the majority of desired correction (80 percent) does indeed come from the first 20 percent of effort, thereby allowing the manager to deploy what would have been largely unproductive effort to more productive output elsewhere (Blair Feltmate, University of Waterloo, pers. comm.). A difficulty for adaptive governance is in the application of this concept more broadly to management decisions. What might make sense for one individual in a social system is often detrimental within a broader context where that decision undermines the condition of the wider system (Meadows, 2008). The difficulty becomes using the techniques of adaptive governance to resolve the most contentious issues most effectively.

Collective Decisions

The history of finding balance in natural resource management can be described largely as one of *command and control* (Holling, 1995). This approach typically targets a single environmental variable (such as the concentration of phosphorus, for example) and management activities are directed at maintaining it at an 'optimal' and sustained level. The success of command and control methods requires significant assumptions about the characteristics of ecological systems, that they are "well-bounded, clearly defined, relatively simple, and generally linear with respect to cause and effect" (Holling and Meffe, 1996). These methods almost always hit a point of diminishing returns (or worse) in a world that is instead found increasingly to be complex, nonlinear, and unpredictable—and management is left therefore with best judgments, not certainties (Holling, 2001). Whether acknowledged explicitly or not, a reliance on judgment in the face of uncertainty is present in all management decisions and actions, and is the fundamental reality that underpins the concepts and methodologies described in this chapter.

There is an increasing appreciation and concern for the role of uncertainty in the management of dynamic environments in the Great Lakes (e.g., Bails et al., 2005). Holling (1973) first replaced the traditional equilibrium notion of resilience as stable ecological systems, with a view of resilience as the capacity for ecological function to persist in the face of change, proposing that "resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist." The complexities and resilience of such environments has attracted considerable attention as a perspective for understanding the dynamics of social-ecological systems

(e.g., Gunderson and Holling, 2002; Folke, 2006; Norberg and Cumming, 2008), particularly with respect to the design of governance institutions (e.g., Lebel et al., 2006).

Decision making is an intensely political process, however, and an appreciation of complexity inherent to a problem situation can be severely constrained by competing interests (Miller, 1999). In this social context, the descriptions of individual conscious and nonconscious decision processes have parallels to collective processes: organizational decision making is habitual, and increased flexibility therefore comes only with significant effort (Miller, 1999; also Holling and Meffe, 1996). In addition, an increasing heterogeneity of stakeholders in environmental management (although not all involved in decision making) has resulted in an increase of the "intellectual and interpersonal complexity" facing those responsible for decision making (Miller, 1999). Further still, complex environmental decisions that involve social-ecological interactions also combine the characteristics of complexity with a continuum in time and space where feedbacks continually alter conditions as we attempt to account for them. The behaviours of complex systems include non-linear dynamics and self-organizing properties that create inherent uncertainties (Gunderson, 2000). Decisions taken in the face of uncertainty, however, do illustrate the flexibility with which people respond to continual (if even only slight) changes in task conditions that can affect their preference judgments, assessments of uncertainty, and choices among alternative actions (Payne et al., 1993). The choice of governance model or policy tool can either suppress or leverage that flexibility.

Practices for a Better Understanding

Despite the Agreement's policy innovations and measured success at improving water quality in the Great Lakes, significant shortcomings in implementation risk its "irrelevancy" (Botts and Muldoon, 2005, also Krantzberg, 2009). At the same time, symptoms of extreme stress in the Great Lakes from a combination of regional and global sources, if not addressed with "great urgency," pose "potentially irreversible" harm (Bails et al., 2005). This assessment of environmental and policy realities is not unique to the Great Lakes but follows a global trend of fraying ecologies, insufficient outcomes, and uncertain futures (MA, 2005; also Gunderson et al., 1995). Such assessments have identified traditional command and control approaches to management as undermining resilience in social-ecological systems such as the Great Lakes, suggesting that those traditions are inadequate for making significant progress towards meeting the purpose of the Agreement to restore and maintain the integrity of the waters of the Great Lakes basin ecosystem. Most significantly for the Great Lakes, jurisdictional and administrative myopia create a social fragmentation that limits our ability to fully realize the potential of an ecosystem approach to addressing the complexities of ecological problems and their underlying human provenance (Francis and Regier, 1995).

Societal responses to environmental decline in preceding decades, as expressed through governmental policy and management, have passed through three overlapping epochs. These are characterized by command and control regulation and compliance, efficiency-based reforms that introduced preventative approaches, and most recently a more comprehensive inclusion of human elements into management (Mazmanian and Kraft, 2009). The history of the Great Lakes regime has mirrored this trajectory, from initial end-of-pipe pollution management through to a model of governance "haltingly evolved" to relate more responsibly to broader ecosystemic properties (Regier et al., 1999). Significant next steps in this evolution must be in the direction of adaptive governance (Manno and Krantzberg, 2008, Folke et al., 2005). The third epoch represents an "Emerging Era" that is self-organizing and open (Regier et al., 1999), characteristics that traditional management frameworks will be unable to comprehend and reconcile (Lubell et al., 2009, Moran, 2010). Devolved power, integration, and collaboration are characteristic of the Emerging Era—qualities requiring a model of governance with more "social responsiveness to ecosystem dynamics" (Folke et al., 2005) and a new role for science that probes uncertainty and facilitates social learning (Regier et al., 1999).

People learn in order to acquire a better understanding of some thing or event. According to Argyris (1993), people organize (in the form of natural resource management agencies, for example) in order to act and to accomplish intended goals (e.g., policy outcomes) that represent or contribute to preferred states of nature (that individuals strive to 'satisfice' by acting). These are the preferences that can be inferred, by observing the actions of individuals acting as agents for the organization, to drive and guide their actions (and are not the underlying beliefs or values people espouse). Figure 2 illustrates Argyris's (1993) contrast of learning cycles defined by the degree of reflection and fundamental change provoked by learning. Single-loop learning occurs when there is a match between intentions and outcomes, or a mismatch is corrected by changing actions. Double-loop learning occurs when mismatches between intentions and outcomes are corrected by examining and altering the governing variables (i.e., underlying preferences and beliefs) and then the actions.[7] Argyris (1993) is careful to emphasize that learning may not be said to occur through the discovery of a new problem or the invention of a solution to a problem. Learning occurs when the invented solution is actually put into practice—an important distinction implying that discovering problems and inventing solutions are necessary, but not sufficient conditions, for learning.

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[7] It may be that societal transformation in the Emerging Era only results from triple-loop learning (Hargrove 2002; also Pahl-Wostl 2009), but because organizational change is overwhelmingly informed by a single-loop (Argyris 1993; also Parson and Clark 1995; Miller 1999), a double-loop reframing of Great Lakes issues, especially where those issues constitute barriers to restoration, would be considered a paradigmatic change in the character of our collective mode of understanding.

FIGURE 2. Single-loop and double-loop learning (adapted from Argyris 1993). People organize (in the form of natural resource management agencies, for example) in order to undertake collective action to accomplish goals. Governing variables are preferred states that individuals strive to 'satisfice' by acting. Single-loop learning occurs when there is a match between intentions and outcomes, or a mismatch is corrected by changing actions. Double-loop learning occurs when mismatches between intentions and outcomes are corrected by examining and altering the governing variables and then the actions. Learning occurs only when a match or mismatch is produced.
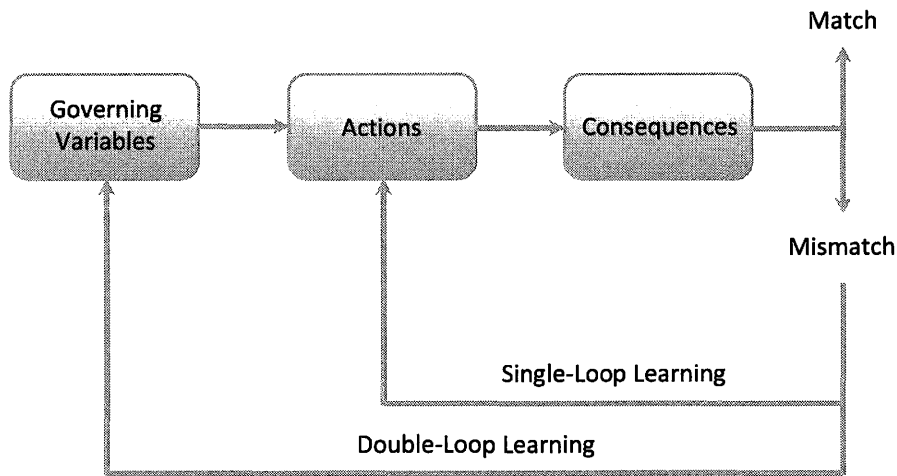
It is significant, therefore, that language added to the Agreement in 1978 instructs the Great Lakes institutional regime, and the federal governments as its signatories in particular, to create such learning. The revisions introduced the often repeated purpose of the federal governments of Canada and the United States: "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem." To achieve this, however, requires the often overlooked remainder of the purpose, that the governments are "to make a maximum effort to develop programs, *practices* and technology necessary for a *better understanding* of the Great Lakes Basin Ecosystem..." (emphasis added; see McLaughlin and Krantzberg, 2006). I draw this out to emphasize the relationship between learning and practice in the purpose of the Agreement. The phrase 'better understanding' acknowledges explicitly the principal insight of Argyris (1993), that a better understanding of the Great Lakes system (i.e., learning) will result from a continual and maximal effort to refine our practice in the service of new knowledge. Finally, learning in this context is not necessarily limited to technical exercises; the concept is widely described as "a set of frameworks, ideas, tools, information, styles, language, stories, and documents" shared by members of a community, be that community defined by technical competencies or more broadly (Wenger et al., 2002).

Adaptive Management

Renowned American forester-philosopher Aldo Leopold (1930) followed in the pragmatic tradition of John Dewey in foretelling adaptive management with the idea of learning through experience in natural resource management: "We conservationists... have many ideas as to what needs to be done, and these ideas quite naturally conflict. We are in danger of pounding the table about them, instead of going out on the land and giving them a trial." This insight is only one of the reasons why Leopold was ahead of his time, and in many ways, is still ahead of our time.

Adaptive management (AM) is principally about learning—but a particular type of learning that Crawford et al. (2005) describe as *the reduction of key uncertainties through management*. A key uncertainty is a "knowledge gap that prevents selection of the suitable management option from alternatives because the impact of various management actions on indicators cannot be predicted with adequate certainty" (AMET, 2003). In this light, the goal of adaptive management is ultimately to fill that knowledge gap.

What AM Is and Not

Every key uncertainty in management is a potential learning opportunity (Grumbine, 1994; Murray and Marmorek, 2003b). The practice of adaptive management can provide reliable information to managers and policy makers about "what works and what does not work" (Stolnack et

al., 2005) because policies are intentionally designed as hypotheses and management is implemented as experiments to test the understanding on which the policies were developed (Holling[8], 1978; Walters, 1986; Lee, 1993). Crawford et al. (2005, 2010) provide a tidy history of AM as a series of evolving operational frameworks (Lancia et al., 1996, Schreiber et al., 2004, and Gregory et al., 2006 are also suggested). For example, Walters (1986) included a structured description that formalized the links between science and policy. He described explicitly how the cyclic character of scientific inquiry (i.e., hypotheses, predictions, tests, and probabilities) was consistent with the cyclic character of policy decision making where "designing adaptive management strategies appears to involve four basic issues:

1. Bounding of management problems in terms of explicit and hidden objectives, practical constraints on action, and the breadth of factors considered in policy analysis;

2. Representation of existing understanding of managed systems in terms of more explicit models of dynamic behaviour, that spell out assumptions and predictions clearly enough *so that errors can be detected and used as a basis for further learning*;

3. Representation of uncertainty and its propagation through time in relation to management actions, using statistical measures and imaginative identification of alternative hypotheses (models) that are consistent with experience but might point toward opportunities for improved productivity;

4. Design of balanced policies that provide for continuing resource production while simultaneously probing for *better understanding* and untested opportunity" (emphasis added).

Adaptive management generates learning because management programs are designed to identify and reduce key uncertainties about resource dynamics by iteratively using feedback information (to inform policy redevelopment) from the system being managed. Figure 3 illustrates this analogy between the policy cycle and the scientific method—a fundamental challenge to (and the basis on which to overturn) the traditional perception of a policy as constituting an answer, rather than being itself a question.

 Active AM imposes rigorous procedures and expectations on managers and participants. Nudds et al. (2003) sketch the basic tenets of this active approach: models of the system under study are developed to explicitly incorporate sources of uncertainty; the development of a management plan that postulates each of those uncertainties as testable hypotheses maximizes available results and potential learning opportunities; and monitoring of implemented management options is used to evaluate the expected performance of those choices. The results of

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[8] Holling was editor but not sole author of this seminal text. His co-authors are almost always overlooked: A Bazykin, P Bunnell, WC Clark, GC Gallopin, J Gross, R Hilborn, DD Jones, RM Peterman, JB Rabinovich, JH Steele, and CJ Walters.

FIGURE 3. Policy as hypothesis, management as experiment (adapted from Nudds 1999; Crawford et al. 2005, 2010). The columns contrast steps of the conventional scientific method with stages of the policy cycle. Policies are formulated to achieve certain goals. Once adopted, those goals direct management actions to be taken, and monitoring informs policy makers on the effectiveness of those actions at meeting those goals. In this approach, resource management as practiced has the potential to become an experimental test of policies. The monitored outcomes of management activities enter a feedback loop that provides reliable knowledge for the potential reformulation of those policies in a manner that parallels how experimental results in science provide for a reconsideration of assumptions and hypothetical explanations of the phenomena under study. Applied to policy cycles in complex systems, this approach to management presumes that policy goals are questions, not answers.
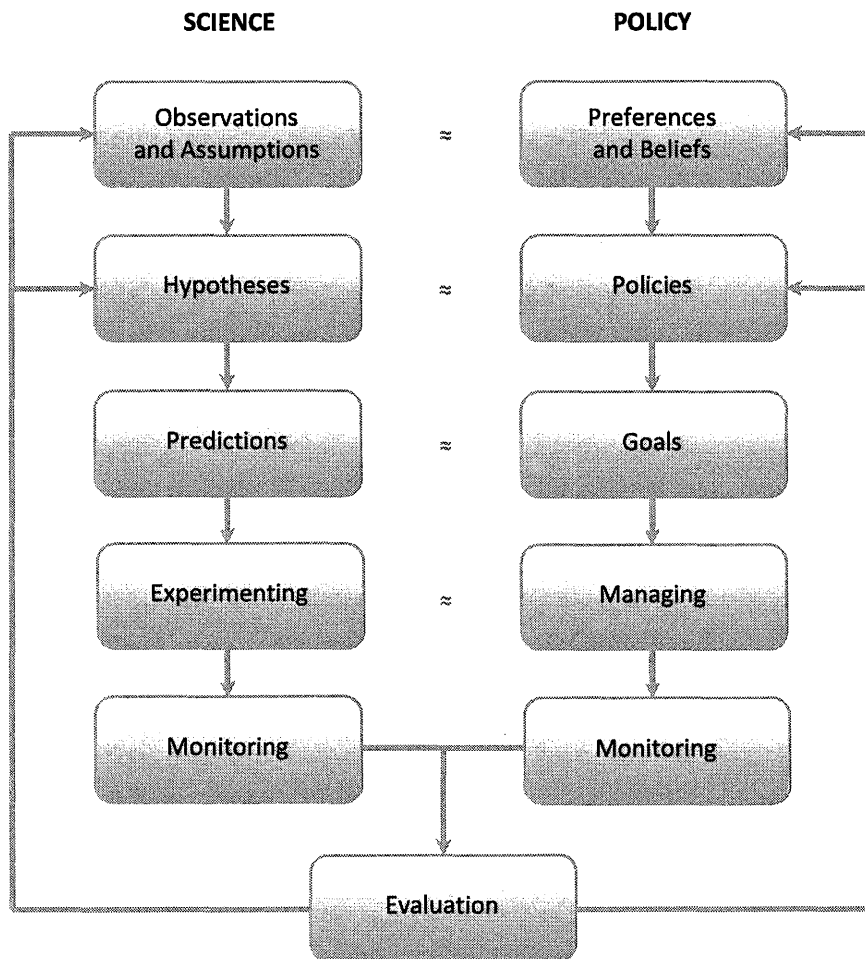
this process are used to adapt and learn—to essentially complete the feedback loop whereby the uncertainties associated with future choices are reduced with the use of new knowledge. It is this final point—completion of the feedback loop with reliable information that informs management—that is a critical and distinguishing feature of active adaptive management. AM is not an attempt to necessarily identify the "best" policy option, but to "embrace uncertainty" by using models and analysis to identify a set of candidate policy options that are all defensible and to eliminate options that are likely inadequate to meet management goals (Walters, 1986). Ideally these candidate policy options are each tested by applying them to the managed system as a set of experimental treatments, either sequentially over time or on a set similar experimental locations. The U.S. Department of the Interior (DOI; Williams et al., 2009) has refined a clear articulation of adaptive management in a standard protocol that follows these steps:

1. involve stakeholders;
2. establish objectives;
3. identify potential management actions;
4. identify models (i.e., hypotheses) about cause-effect;
5. identify and design monitoring plans;
6. select management actions;
7. monitor system responses;
8. assess predicted changes against observed changes; and
9. iterate through the adaptive management cycle.

Crawford et al. (2010) suggest that "it would be difficult to find a more succinct and structured presentation of adaptive management principles and processes for use by resource management agencies."

Alternatively, *passive* AM typically employs historical data from the managed or comparable areas, and a 'best guess' hypothesis and preferred actions are developed. Outcomes are monitored and the data are updated with the new information. Gregory et al. (2006) note that this approach can make good sense when uncertainty is low, or when regulatory constraints (on ecological variability) are high—but in practice, they explain, passive AM is often simply basic trial and error learning that is slow and superficial due to an absence of explicit hypotheses and adequate monitoring, and is without clear implications for management practices. There is a real potential for error, they warn, "because complex interactions and cumulative effects may confound results and analyses." Whether active or passive, adaptive management is done when the simultaneous goals of achieving management objectives and acquiring reliable knowledge are accomplished (Lancia et al., 1993, 1996) and new knowledge is incorporated purposefully into a decision process that allows for the reduction of uncertainty and therefore learning.

As a tool to learn deliberately from the outcomes of management action, adaptive management is intuitively attractive. To employ a scientific approach to managing ecosystems in the face of unwieldy uncertainty is impressive and "easy to understand—almost" (Lee, 1993). *Almost* because adaptive management is widely misrepresented, and often misunderstood fundamentally (Lee, 1993; Murray and Marmorek, 2003a; Schreiber et al., 2004; Allan et al., 2008). Common misconceptions about adaptive management include that it is (after Murray and Marmorek, 2003a):

- trial-and-error (i.e., without a directed research component to management);
- spurious adaptation of policies as you go (simply in reaction to unfolding events);
- sophisticated modeling skills and tools alone;
- consensus from all stakeholders (even when informed by information feedbacks),
- something only scientists do; or
- a panacea that can solve all problems.

Despite the continued evolution of step-wise procedures and the growing enthusiasm for the process of *learning while doing*, adaptive management "has been much more influential as an idea than as a way of doing conservation" (Lee, 1999; also Allan and Stankey, 2009). In the Great Lakes that enthusiasm for adaptive management is present in plans to develop a nearshore framework to address some of the most acute ecological degradation that occurs at the human-environment interface, and that the "cornerstone" of this framework is to be the "adoption of an adaptive-management strategy..." (IJC, 2009b).

When to Use AM and Not

Argent (2009) states that successful adaptive management requires "clear objectives, data and knowledge, the right participants, science skill, willing partners, and money and time." But because uncertainty and unpredictability in social-ecological systems can also produce political, social, and economic surprises, we must be prepared to rationalize the use of any management tool in a broader context, including the use of adaptive management. Gregory et al. (2006) suggest that because adaptive management is as widely misunderstood as it is widely promoted, its track record is weak and many adaptive management initiatives exhibit few or none of the characteristics generally considered essential (see also Lee, 1999; Walters, 2007). There are legitimate examples of adaptive management, according to Gregory et al. (2006), but "other cases share little more than the same name." Or as Crawford et al. (2010) suggest: "When in doubt regarding different ideas called 'Adaptive Management', we strongly recommend that the reader keep their attention focused on the essential role of hypotheses (possible cause-effect explanations, models) and predictions in the AM learning cycle; if these concepts

are absent or vague in the discussion, then—in our opinion—the authors are not discussing Adaptive Management."

Gregory et al. (2006) suggest that the misapplication of AM techniques—the "dark side" of the attraction to AM—means that projects are often not clear what constitutes learning or how much of it is required. Further problems include that the initiation of an AM program will allow for postponement of difficult decisions that hide behind resource constraints and scientific uncertainty, and that AM will result in the design of large, long, costly experiments that come at the expense of other important environmental, social, or economic objectives. The British Columbia Forest Service successfully used adaptive management to evaluate forest-harvest techniques with limited geographical scope beyond the treatment locations (Sit and Taylor, 1998). Schmiegelow and Hannon (1993) and Schmiegelow et al. (1997) describe an experimentally-manipulated commercial forest harvest in Alberta over large spatial scales. Similarly, AM programs in the Florida Everglades (Walters et al., 1992) and the Columbia River basin (Lee, 1993) have been conducted over large geographical regions. In fact, Williams and Johnson (1995), Williams et al. (1996), and Johnson et al. (1997) document a North America-wide AM program for the renewable harvest of mallard ducks.

Formal and thoroughly-documented examples of adaptive management in the Great Lakes are rare and usually related to fisheries (Jones, 1999; M. Jones, personal communication). Walters (1997) reported that of 25 major AM planning exercises that he had participated in, only seven resulted in experiments of an appropriate scale, and only two could be considered well-planned in terms of statistical design. The others, he noted, either "vanished with no visible product" or became "trapped in an apparently endless process of model development and refinement." How are the managers, analysts, and participants of future adaptive management initiatives to avoid being likewise misleading and ineffective? Gregory et al. (2006) suggest that the most significant obstacle to successful adaptive management is the context for identifying and defining the problems to which AM might be applied, and that this obstacle may have more to do with the indiscriminate choice of contexts within which AM is applied than with AM itself. To help avoid this misapplication, Gregory et al. provide criteria to help practitioners decide on the appropriateness of using AM in a given management situation (Table 1). A full discussion of their criteria is beyond the scope of this chapter, but the criteria are provided here because they are an excellent overall sketch of the social-ecological context for adaptive management. Finally, in order to provide a brief look at AM in action, Box 1 provides a short overview of the use of AM in a science-policy problem situation involving the management of the invasive sea lamprey in the Great Lakes (based on Hansen and Jones, 2008).

Decision Analysis

Decision analysis (DA) is principally about uncertainty. Lindley (2006) explains the principal feature of DA: in the event of a problem of which you are uncertain, "you have to do something, you have to act. Thinking about the act involves not only uncertainty... but also the possible consequences of your action." And so what we require is a measure of how desirable the outcome could be, a method "to explore the manner in which desirability and uncertainty may be combined to produce a solution to your problem. This method is called decision analysis because it permits you to analyze the manner in which you ought sensibly to decide." Put another way, decision analysis (DA) is a structured way to think about decisions, providing a procedural structure within which a decision maker can develop beliefs and feelings into those subjective judgments that are critical for a good solution (Clemen and Reilly, 2001).

A decision may also involve several and varied uncertainties that may interact "in tangled ways" to determine ultimate consequences (Hammond et al., 1999). To be useful, uncertainty must therefore be simplified to capture its essential information about its effect on possible choices by describing the key uncertainties, the possible outcomes of these uncertainties, the chances of each outcome occurring, and the consequences of each outcome. DA is intended to deal with surprises in this regard by explicitly and quantitatively considering the implications of uncertainties for decisions (Peterman and Peters, 1998). It is this unambiguous and quantitative approach to decisions that can reduce the arbitrary nature of those decisions by explicitly incorporating uncertainty into the evaluation of alternatives to maximize the probability of choosing the most beneficial option (Raiffa, 1968). More specifically, decision analysis treats both our belief in a particular outcome in terms of a probability, and our satisfaction with that outcome. Lindley (2006) emphasizes that belief and satisfaction are quite separate elements of the same event, and that decision analysis is "a method of making the uncertainties and the qualities of the outcomes combine, leading to a sensible, coherent way of deciding how to act."

DA uses probabilities to quantify the consequences of a set of possible actions given the uncertainties in our current knowledge, with the benefit that "uncertainty is handled in a consistent and systematic way rather than being ignored" Hilborn and Ludwig (1993). It has been suggested (Peterman and Anderson, 1999) that managers of natural resources have historically addressed uncertainty with the following methods:

- *best point estimates* for parameters and state variables that describe system dynamics (although uncertainty is not considered once the parameters are estimated);
- maintaining the *status quo* (when managers are reluctant to revise their policies precisely because outcomes of actions are very uncertain);

TABLE 1. Summary of proposed criteria for deciding whether and how to use adaptive management (AM) (adapted from Gregory et al. 2006).

Topic-area consideration	Criteria questions
Spatial and temporal scale	
Duration	Is the project timeline to obtain verified results compatible with management decision-making requirements?
Spatial extent and complexity	If spatial extent or complexity is large, are there opportunities to apply AM on a subset of the problem and scale up?
External effects	Have potential issues related to background trends and cumulative effects of management actions been addressed in the AM design?
Dimensions of uncertainty	
Parameter uncertainty	Has the AM design been pared down to focus on only those uncertainties most likely to influence management decisions?
Structural uncertainty	Are there profound structural uncertainties? If so, how will surprise outcomes be managed?
Stochastic uncertainty	How do low-probability random natural and other causal events affect the AM design and expected outcomes?
Confidence in assessments	If the confidence in the proposed AM design is low, can expert judgment or other techniques help?
Costs, benefits, and risks	
Specifying benefits and costs	Can all the costs and benefits (and risks) be documented and communicated in a manner understandable to all stakeholders?
Magnitude of effects	Will the information collected through AM have sufficient predictive ability to make a difference to managers?
Multiple objectives	Does the design and assessment of AM plans explicitly address the multiple goals of stakeholders (rather than only scientists)?
Perceived risks of failure	Can stopping rules and clear thresholds identify and/or minimize the perceived risks of failures, to species and to institutions?
Stakeholder and institutional support	
Leadership	Is there explicit policy guidance and leadership support for AM? Will stakeholders see AM as an effective way to deal with uncertainty?
Flexibility in decision making	Is there sufficient management flexibility (and continuity) to incorporate new information in revised experimental designs?
Avoidance of taboo trade-offs	Does the proposed AM design involve any trade-offs that might be considered taboo by some stakeholders?
Institutional capacity	Are sufficient analytical skills available (staff or contractors) to design, evaluate, and monitor AM plans?

- *aggressive policies* for management interventions when the pressure for large, short-term economic yields is high and potential negative consequences cannot be demonstrated convincingly;
- application of somewhat *arbitrary safety margins* or other precautionary actions (when risk is assumed to be high); and
- explicitly and quantitatively consider the implications of uncertainty for decisions using a technique known as *decision analysis* to unambiguously reduce the arbitrariness of decision-making.

It is recommended that readers consult Crawford et al. (2005) for a concise overview of the historical development of DA—"making hard decisions in the face of uncertainty"—and Miles (2007) for a thorough history. Additionally, a review of the development of DA operational cycles is beyond my purpose, although this was done by Crawford et al. (2005) who include the cycle of Clemen and Reilly (2001), a standard DA reference in the natural resource management literature, but favour a variation developed in Peterman and Peters (1998) and Peterman and Anderson (1999).

Embracing uncertainty, or at least attempting to handle it, means that we must measure our beliefs through probability, both to see how they combine (i.e., how the beliefs of more than one person can be made to cohere with one another) and how they change with new information (Clemen and Reilly, 2001; Lindley, 2006). It is critical to appreciate that DA deals with "beliefs in action" by analyzing "how you might decide between different courses of action, without saying what the decisions should be, only how they should be organized" (Lindley, 2005). As with AM, formal and thoroughly-documented examples of decision analysis in the Great Lakes are rare and usually related to fisheries (see Crawford et al., 2005; Jones and Bence, 2009; and Jones et al., 2008; but Schleen et al., 2003 on sea lamprey). Finally, in order to provide a brief look at DA in action, Box 1 provides a short overview of the use of DA in a science-policy problem situation involving the management of the invasive sea lamprey in the Great Lakes (based on Haeseker et al. (2007)).

BOX 1: Learning to manage sea lamprey.

The Great Lakes have proved vulnerable to the introduction of aquatic invasive species (AIS), or non-native plants and animals, many of which (such as the sea lamprey) have significant ecological and economic consequences. The IJC (2009a) estimates that there have been about 180 such introductions into the Great Lakes. Francis and Regier (1995) note that each of the Great Lakes has seen a widespread disappearance of most native trout and salmon species, with predation by the sea lamprey a primary cause of the extirpations (along with excessive predation by humans). The Great Lakes Fishery Commission (GLFC) was established in 1955 primarily to direct

control of the sea lamprey, an eel-shaped organism that parasitizes other fishes. The GLFC is the major decision-making authority in sea lamprey management, and more than fifteen million dollars (U.S.) is spent annually on controlling sea lamprey populations using periodic treatment of spawning streams with a lampricide. Generally, high uncertainty surrounds our limited knowledge of AIS biology, behaviour, and ecosystem impacts, however, complicating the relationship between AIS research initiatives and the development of AIS management protocols (IJC 2009a). The two sections below highlight aspects of recent Great Lakes research relating to AIS protocols that employed adaptive management and decision analysis. The purpose is to illustrate rare examples where management objectives inspired research design *and* the findings explicitly informed a rigorous reconsideration of the objectives.

Sea lamprey and adaptive management

Hansen and Jones (2008) developed and evaluated an alternative method (rapid assessment or RA) of assessing the extent and location of lampricide application. Sea lamprey life history does not require that every stream be treated each year in order for treatment to be maximally effective. However, natural variation in population characteristics makes it impossible to predict with certainty when each stream will require treatment. Their objective was to compare the performance of the RA method against the current assessment method (quantitative assessment sampling or QAS). They assumed that the RA method would be less accurate but less costly (due to fewer requirements of the sampling and ranking methods), and that assessment cost savings could be added directly to the treatment budget in order to treat additional streams. They hypothesized that allocating fewer resources in assessment would therefore mean greater suppression of sea lamprey across the Great Lakes. They provide a summary of the significant differences between QAS and RA, and descriptions of their larval sampling and stream ranking procedures.

Hansen and Jones determined that using the RA method to select streams for treatment would result in at least as much or more sea lamprey mortality than the QAS method. Their study is a rare example of adaptive management implemented properly because the two differing management activities (the RA and QAS assessment to inform lamprey treatment options) are posed explicitly as competing hypotheses with testable predictions. They do note that their "experiment is not a traditional example of adaptive management, because assessment options rather than control options are being compared. However, because we compared assessment methods that have a minimal effect on the system being observed, we were able to apply both assessment methods to the same set of streams in each year of the study and directly compare the results." Determining the current status of a population is a critical component of many re-

source management programs, they further note, and suggest that "this research is broadly applicable not only to sea lamprey management, but also to managed systems in general."

Moreover, Hansen and Jones report that beyond the insights from their research with direct linkages to future management, the GLFC (which had provided funding for the research) decided to adopt the RA protocol for ranking streams beginning in 2008, and that "in the spirit of adaptive management, managers and biologists will continue to monitor populations of sea lampreys and native fishes to assess the performance of RA and adjust the protocol as necessary to best meet management goals." Indeed, the GLFC saved approximately $300,000 (U.S.) by employing the RA method rather than the QAS method that had formally been used, and similar savings have been realized during the years following and were then used to conduct additional lampricide treatments (Michael Siefkes, GLFC, Ann Arbor, Michigan USA, pers. comm.). Hansen and Jones conclude by noting that "the use of adaptive management to test new methods of assessment and resource allocation is a means through which the optimal balance of resource demands can be determined and should be applied to other systems."

Sea lamprey and decision analysis

Haeseker et al. (2007) designed a decision analysis (DA) to assist the GLFC (which partially funded the research) in facing the challenge of developing feasible long-term control strategy for effective control of sea lamprey in the St. Marys River. The project went on the assumption that a DA "could provide a process for formally considering the uncertainties that made development of an optimal strategy so difficult" to reconcile with many competing management priorities.

Haeseker et al. followed the eight-step DA process outlined by Peterman and Anderson (1999) and also endorsed by Crawford et al. (2005). They convened a meeting of scientists, management agency personnel, and other stakeholders to describe the DA process and identify candidate sea lamprey control actions, and describe subsequent discussions of the attributes and costs (i.e., the uncertainties) of each possible action. Defining the management objectives proved more difficult, they report, although with a carefully selected group of experts (i.e., any stakeholder substantively engaged in the issue) they are able to narrow the list of uncertainties to a small number that dominate in the decision process. Haeseker et al. then used a variety of methods to assign probabilities to uncertain future states of nature and then modeled forecasts of possible outcomes based on the range of management options. The decision problem was visualized using a decision tree depicting "the management options and the critical uncertainties that may influence the expected performance of different management options." Haeseker et al. used a variety of performance measures to rank the outcomes of ten management options (which in a DA are described in terms that relate directly back to the management objectives,

such as economic value or mortality rate). To determine whether the rank order of the ten management options (as preferences, given all factors given weight in the decision) changed with different assumptions, Haeseker et al. performed a sensitivity analysis that showed that the conclusions of the analysis were independent of the choice of performance indicator, meaning that the conclusions were robust.

As in the adaptive management example, the GLFC used the research findings to guide future management decisions. Haeseker et al. explain that there were three consequential outcomes to their analysis: "First, our explicit consideration of uncertainty altered the choice of management option made by the GLFC... Second, the analysis allowed the GLFC to justify a compromise management option that reflects a balance of short- and long-term interests. Third, the analysis cemented support for ongoing assessment in the St. Marys River to inform future decisions."

DAAM

Despite the strengths of adaptive management to generate learning, any particular process of investigation through management, adaptive or not, must usually consider more than one candidate policy option. Each of these options will inherently embody uncertainty from the complexity and variability of the problem situation, and from both the sampling and modelling error that occurs in trying to quantify and describe the system (Peterman and Peters, 1998). Resource management has historically failed to address uncertainty, or has done so with arbitrary means in the absence of good understanding or appreciation (Hilborn and Ludwig, 1993; Peterman and Anderson, 1999).

Adaptive management is a set of techniques to improve understanding, but alone it is not a decision process or model (Argent, 2009). Adaptive management can *contribute* reliable knowledge to decision making through the generation of learning, but the modification of behaviour (such as some element of management) subsequent to learning must result from a decision process. Decision analysis is such a process. AM and DA are more than complementary: "they need each other" because together (i.e., DAAM) they are "all about making hard decisions in the face of uncertainty *while* reducing key uncertainties through management" (Crawford et al., 2005; their emphasis). Although the scientific aspect of AM can leave managers and other stakeholders believing that important non-scientific questions or issues are subservient to some higher calling to learn, the DA process in fact helps AM to capture those issues and beliefs in a very transparent and accountable way. Similarly, DA on its own can be a useful tool for managers to organize their possible actions into a framework that explicitly incorporates their key uncertainties about the likely consequences of various decisions to act, but that if an uncertainty is

significant enough to be included in a formal DA, then it is important enough to use AM as a tool to reduce that uncertainty.

Figure 4 illustrates how the principles of DA and AM combine to create four shared principles of DAAM that reflect the shared history of DA and AM from a "common lineage of thought" on the role of uncertainty in resource management: non-exclusive participation, explicit management objectives, probabilities of competing hypotheses, and valued reliable information (Crawford et al., 2005). Jones and Nudds (2003) capture the essence of DAAM in that "AM without DA is inefficient and DA without AM is unfinished business"—inefficient because information gained through an AM program without DA would not necessarily lead to improved policy revisions in future, and unfinished business because for such reductions to be achieved a DA process requires the reliable information gained through AM. The cyclic, rigorous power of DAAM derives from the use of DA for organizing and choosing actions and AM for assessing their effectiveness. This ultimate meaning of the DAAM approach was articulated by Holling (1978) in stating that "it should be clear that the real problem of evaluation is not one of technique, but of meaning... [that] the ultimate goal is not to produce a set of numerical rankings, but to understand the strengths and weaknesses of alternative policies' performances. For it is on the basis of such understanding that meaningful, adaptive steps can be taken toward policy modification, improvement, and eventual implementation."

Furthering a better understanding as it has been described in this chapter will be the hallmark of an adaptive governance model. This defining characteristic is captured in the term *value of learning* (VOL), as it recognizes learning explicitly as a core management objective with benefits to a decision process that can be defined and evaluated (McDaniels and Gregory, 2004). The VOL recognizes that many aspects of a decision can benefit from learning, including a better characterization of the objectives, the suggestion of new options (including ways to better implement existing options), creation of a performance measure for learning, and improved understanding about consequences and tradeoffs between learning and other objectives. In addition, learning can occur for related decisions outside the current decision context, and hence, the VOL can be extremely high where many related decisions that have recurring elements, common features, and high stakes are affected. The VOL is perhaps the most elegant description of how AM can be integrated explicitly with DA in resource management decision-making (Crawford et al., 2005).

FIGURE 4. Essential principles of Decision Analysis, Adaptive Management, and DAAM as combined and illustrated by Crawford et al. (2005). According to Jones and Nudds (2003), DA and AM are more than just complementary, as that would imply that they are not necessarily co-dependent but exist merely adjacent to each other. Indeed, AM without DA is inefficient, and DA without AM is unfinished business. The four shared principles represent the full breadth of DAAM, involving fully people, uncertainty, choices, policy, management, and learning.
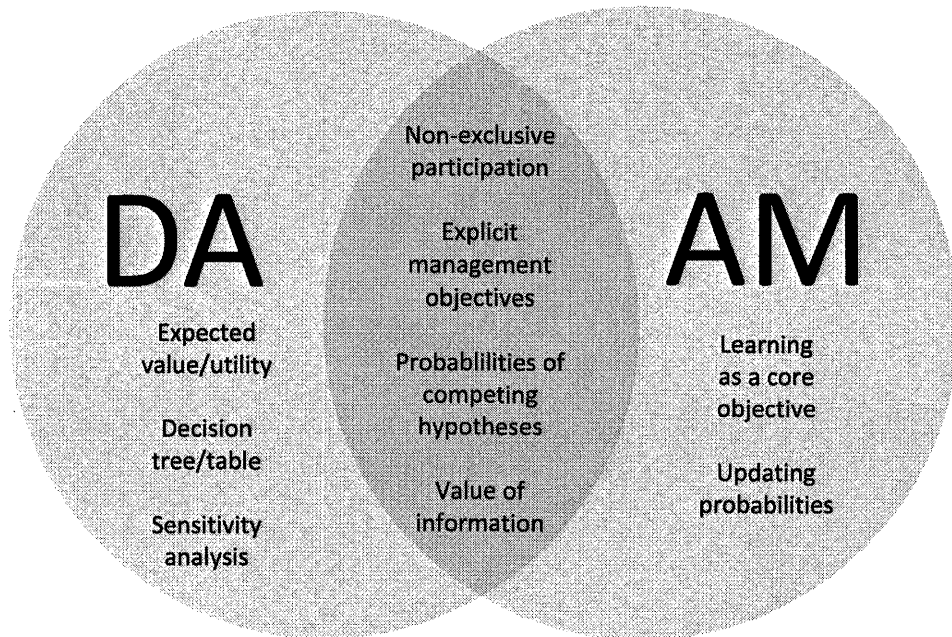
Research Context for DAAM in the Great Lakes

Actual applications of active processes of DAAM in the Great Lakes—management activities *and* decision processes to make hard decisions in the face of uncertainty *while* reducing key uncertainties through management—have been exceptionally rare. Elsewhere, major components of both DA and AM were present in an integrated approach to an Australian multispecies fishery (Sainsbury, 1987, 1988, 1991; Sainsbury et al., 1993, 1997). These researchers demonstrated how DA could usefully compare experimental and non-experimental strategies with respect to economic performance of management options. In an unpublished masters thesis at the University of British Columbia, Ohlson (1999) explicitly combined DA and AM to apply to a land use conflict with chronic uncertainty. Benefits of DAAM in the circumstances that he investigated were its ability to reveal the effects of key uncertainties on the ranking of alternative management actions, and to increase confidence among stakeholders because of the significant demands that DAAM places on transparency and accountability. David Marmorek and colleagues, principally at ESSA Technologies Ltd. in Vancouver (e.g., Deriso et al., 2001, Peters et al., 2001, Marmorek and Peters, 2002), have developed and implemented arguably the most sophisticated DAAM process for recovery of depleted and endangered populations of Columbia River chinook salmon. Overall, their research demonstrated that robust recovery strategies could be identified before uncertainties were fully resolved, which may not occur until the stocks have disappeared.

The purposeful development of DAAM in the Great Lakes region has been driven by Mike Jones of Michigan State University and Tom Nudds of the University of Guelph (e.g., Jones and Nudds, 2003), and by Steve Crawford at the University of Guelph in conjunction with the Chippewas of Nawash First Nation on the Bruce Peninsula in southwestern Ontario and the Ontario Commercial Fisheries' Association (e.g., Crawford et al., 2005). Linkov et al. (2006) were also developing DAAM-related concepts, but with only marginal and non-specific reference to the Great Lakes. Adaptive management is an organizing principle in the Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem (Canada and Ontario, 2007), the IJC's International Upper Great Lakes Study (IJC, n.d.), and the IJC's developing Nearshore Framework priority (IJC, 2009b). There are other examples of AM programs (e.g., MacDonald et al., 1999), but none are coupled explicitly with DA. Perhaps the one area of Great Lakes management with an effective history of active AM is sea lamprey control, where many sea lamprey control programs have contained elements that are arguably consistent with adaptive management principles of using science to inform policy by formally evaluating performance of management and adjusting policy as learning is achieved (M. Jones, personal communication). Decision analysis has also been applied in a Great Lakes fisheries context, including for management of the salmon fishery in Lake Michigan and of the walleye fishery in Lake Erie (S. Crawford, personal communication).

Again, the reader is referred to Box 1 (mindful that these two examples are not explicitly DAAM). Currently, there are three active research programs focused on the development and application of DAAM for Great Lakes fisheries management, including for Lake Huron fisheries management, Lake Erie walleye and yellow perch fisheries management, and for the Great Lakes Fishery Commission's ecological review of exotic salmon stocking in the Great Lakes Basin (S. Crawford, personal communication).

Policy Context for DAAM in the Great Lakes

It follows from the purpose of the Agreement, "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem" to ask: restore and maintain at what identifiable endpoint? This question represents a fundamental tension in ecological restoration because defining what measureable degree of restoration is both attainable and acceptable is highly contestable. Adaptive governance is critical to resolving these types of questions—especially when we must cope with uncertainty in our knowledge and with competing preferences and beliefs as the primary context for decision making.

The IJC's Science Advisory Board's (SAB) contribution to the IJC's 1999–2001 Priorities Report (IJC, 2001) recommended that the IJC "comprehensively identify and review emerging issues." A principal objective of the SAB's emerging issues workshop in 2003 was to identify "specific initiatives that represent the most promising future opportunities for sustaining progress" under the Agreement (IJC, 2003a). The workshop concluded that the institutions of the Great Lakes are fundamentally unable to stop new and re-emerging stressors without a renovation of their governance structure, and that the Agreement should be examined for opportunities to improve integration between science and policy. Science and policy have a tendency to be "overcompartmentalized, with policy frequently lagging behind current scientific understanding" it was also concluded, and therefore that greater institutional capacity is required to reduce scientific uncertainty (IJC, 2003a). However, there is a lack of flexible institutional structures that would enable us to synthesize and learn from that future research, and these structures will be required so as to form coherent policy based on a more systemic understanding of Great Lakes systems for decision making (McLaughlin and Krantzberg, 2006).

Could a reinvigoration of Remedial Action Plans (RAPs) provide the type of institutional structure needed to pursue DAAM initiatives? RAPs have proven difficult to develop and implement over the long-term because of difficulties in sustaining progress and in maintaining continuous and vigorous oversight. However, RAP governance models could be well-suited to incorporate DAAM processes because RAPs were designed to be mechanisms to "harmonize and achieve" the interdependent goals of environmental, social, and economic development (Hartig and Zarull, 1992; also Sproule-Jones, 2002; Krantzberg, 2003, 2006). RAP processes may also be

suitable for DAAM because beyond institutional structure, mere participation in RAPs exhibited uncertainties: cost uncertainty (e.g., who is going to pay for this, and will it be more than projected?), cause and effect uncertainty (e.g., do we understand what is going on, and do scientists and lay stakeholders share the same concerns on issues such as sediment remediation or habitat restoration?), trust (of each other) and other elements of social cohesion (such as defining and sharing responsibilities), valuations of nature (e.g., how to agree on ranking one beneficial use over another, and answering what endpoint is sufficient?), and uncertainty that all the effort will be worth it in the end.

Is there evidence that an adaptive governance approach could be possible in the Great Lakes? In an authoritative chronicle of the Agreement's history, Botts and Muldoon (2005) suggest that several features of the Great Lakes regime have contributed to it success, three of which I highlight below as possible contributions to creating the conditions for adaptive governance with a more rigorous and inclusive approach to collective decision making in the Great Lakes.

Joint Fact-Finding and Research

The Agreement obliges both federal governments to contribute to research and monitoring needs identified through the IJC in addition to their individual research programs. The Agreement also goes beyond the Treaty's short-term application of this function in recognizing the necessity for ongoing research and joint monitoring to measure progress and identify emerging problems. Joint fact-finding has evolved with the regime, contributed to the development and acceptance of new concepts (such as the weight of evidence approach), stimulated debate about how to make decisions in the face of incomplete knowledge, and enhanced the credibility of the IJC (Botts and Muldoon, 2005). Joint fact-finding benefits our collective construction of knowledge and understanding (Andrews, 2002). However, as responsibilities have evolved with revisions of the Agreement, a decline in the capacity of the IJC to collect and analyze data makes the impact of joint fact-finding uncertain. In particular, the change in the role of the WQB from evaluating government programs and progress toward meeting Agreement objectives to simply policy advisor to the IJC created a gap in gathering and analyzing information (Botts and Muldoon, 2005).

Accountability and Openness in Information Exchange

There are several mechanisms in the Agreement intended to foster accountability and openness, which in turn promotes involvement and a sense of community among numerous and diverse Great Lakes interests, including the requirement for regular progress reports by the advi-

sory boards to the IJC and by the IJC to the governments (to be followed by the responses of the Parties to the IJC), and the requirement for periodic review of the Agreement itself (Botts and Muldoon, 2005). All aspects of those processes are (relatively) open to public scrutiny, and the Great Lakes Regional Office is directed to provide a public-information service on the programs of the Agreement. The governments have allowed observers to attend BEC and SOLEC meetings, although they have not actively sought or promoted public participation at these events. Additionally, the public participation in its biennial meetings that has been promoted historically by the IJC, including participation from industry, civil society, professional organizations, has diminished since the 1990s (Botts and Muldoon, 2005). And the highly superficial engagement of non-governmental stakeholders in the 2010 renegotiation of the Agreement has been the subject of significant criticism based on concerns that it will undermine confidence in the final revised Agreement (e.g., GLU, 2010).

The joint nature of many research programs under the Agreement has encouraged scientists to share research outcomes not just with each other, but with program managers, policymakers, legislators, and activists in the larger community. This practice of social learning has engendered at times a camaraderie among government-agency officials, IJC staff, scientists, staff and members of environmental organizations, and political leaders and their staff (Botts and Muldoon, 2005). Furthermore, because the Great Lakes policy regime is founded on the 1909 Boundary Waters Treaty that established the IJC, those relationships between stakeholders benefits from historical, relatively stable, and ongoing established processes that would be vital to establishing adaptive governance structures that combine science and society—largely because of the commitment and leadership that is required, and because of the local and regional processes in which an organization such as the IJC is logically and historically positioned to play a central role. "The triumph of using the IJC to avoid disputes about use of the waters under the treaty," state Botts and Muldoon (2005), "set the stage for the challenge of restoring ecological integrity under the Great Lakes Agreement."

Flexibility and Adaptability to Changing Circumstances

Most international agreements are adopted to solve a specific problem or resolve a specific dispute and have little ability to accommodate significant related issues. The flexibility of the Agreement results from the periodic reviews that are required to assess progress and to allow consideration of changes to any element of its programs (Botts and Muldoon, 2005). Those changes provide opportunities to apply new knowledge and adapt the objectives of the Agreement to changing circumstances, despite that these opportunities may have been underutilized in the past. It is this ability to apply new knowledge that suggests that the Agreement may be amenable to DAAM processes and feedbacks in the manner illustrated in Box 1.

Elements of DAAM Accountability

The federal governments have various obligations to report, explain, and/or justify actions they take to fulfil the purpose of the Agreement. Some of that responsibility is shared (under varying circumstances and jurisdictional authority) with stakeholders such as provincial and state agencies and a growing list of others with a desire to participate in management and restoration activities. These additional stakeholders represent a cross section of society, such as civil society groups, First Nations and Tribes, industry and trade organizations, municipal governments, professional organizations and academics, and individual citizens. However, it is critical to appreciate that despite the challenges involved in facilitating a wider participation in decision making, the principles of DAAM actively require this participation. The shared principles of DAAM as illustrated in Figure 4—non-exclusive participation, explicit management objectives, probabilities of competing hypotheses, and the value of information—are the foundation for accountability in DAAM processes, as they direct who is involved and require substantial trust and openness, and transparency. The principles also incorporate to two overarching characteristics of management that require special focus under DAAM: the *technical design* elements of DAAM necessary for proper implementation, and the institutional insights to improve the *governance structure*, particularly transparency and accountability, necessary to operationalize DAAM. The former without adequate attention to the latter will significantly undermine the robustness of the process, particularly as DAAM is an inherently social process.

Norton (1995) states that "environmental management faces a crisis" in that domestic legislation and international agreements all urge that natural systems be managed to protect system health and integrity. However, the design of such laws and institutional arrangements have not yet developed a consensus in operational management directives, and therefore we have not typically seen the kinds of significant changes in management and decision-making necessary for DAAM initiatives. The challenge of creating such change is hindered in the Great Lakes by multiple uncertainties and multiple institutional actors and priorities. I emphasize that the practicality of applications of DAAM (i.e., careful case selection in future), the importance of stressing process and not prescribing recipes, and the importance of cultivating relationships and commitments across stakeholder groups will underpin whether attempts to incorporate DAAM into existing or future Great Lakes management programs succeed. Authors and practitioners indicate that common themes of DAAM success include the importance of leadership, partnerships, 'closing the loop' to management, and organizational commitment and resources. These themes are all critical issues of accountability, too, because where DAAM is concerned with appropriate balance between management objectives and learning objectives, compromise is usually required to maximize learning and minimize risk (Murray and Marmorek, 2003a).

Allan et al. (2008) detail three strategies for building adaptive organizations and processes that engage the those with primary responsibility for programs with support staff and outside stakeholders and I abbreviate these three strategies as follows. Strategy 1 encourages practitioners and their leaders to <u>define adaptive management, focus and be purposeful</u>, that as a pre-requisite for other actions, proper adaptive management programs "must be recognized as a radical departure from established ways of managing natural resources. Adaptive management is not 'business as usual', nor should it be seen as an excuse to muddle through management problems." In this respect, organizations and their leaders must create the conditions for managers to be adaptive and reflective by defining the context in which appropriate management actions can occur. DAAM will require champions who have (or who have been given) the time, resources, capacities, and responsibility to influence how policy is devised and how it is implemented. When such leadership is in place purposeful activities can be developed and implemented (Allan et al., 2008).

Strategy 2 advocates that practitioners and their leaders <u>encourage and support evaluation</u>. Evaluation considered as a stage in learning and not as mere auditing is central to the adaptive management process. For example, research and coordination can often mean conducting inventories, which does not meet the requirement for learning. Evaluation also requires that the necessary institutional space must be actively created to allow genuine reflection on processes and outcomes. Creating such space requires a reassessment of institutional incentive systems, and there must be an acceptance of the limits of knowledge and the possibility of errors and mistakes (Allan et al., 2008).

Strategy 3 is a directive to <u>collaborate and integrate</u>. Participatory approaches require a recognition and acceptance of the multiple ways of knowing and understanding. However, social learning processes cannot be simply lifted from the page and applied (Keen et al., 2005). The legitimacy of knowledge and learning that underpins management decisions must be clarified, especially when integration of scientific and other forms of knowledge generation are proposed as it is explicitly in DAAM. Ultimately, DAAM strategies turn accountability from being merely responsive (e.g., to reporting requirements) into an incentive to lead.

Uncertainty and Learning in the Great Lakes

The focus of this chapter has been on how we might better integrate priorities and uncertainties about the future of the Great Lakes, and in the process improve the accountability, responsiveness, and efficacy of restoration policy and decision making. Research into decision making has traditionally focused on how individuals choose among alternatives to make the 'right' decision. Three traditional assumptions about the creature known as *homo economicus* (Lee, 1971) are that the rational decision maker is thoroughly informed, is infinitely sensitive and discriminating,

and possesses the rational capacity for ordering alternatives so as to maximize something. However, we now know that decisions are almost always taken in the context of incomplete knowledge, a reality imposed by inherent uncertainties in complex systems of people and nature. Whether people individually make rational choices is somewhat beside the point, at least in the context of requiring a forum for the open exchange and reconciliation of a broad range of differing and often conflictual perspectives. A corollary of that diversity of opinion is the expectation of disagreement about what we should maximize (and why).

Decision making cannot be thought of as an event, decoupled from our continuous coping in the face of the complexity and uncertainty that characterizes human-environment interactions. The question is how do we properly attend to significant threats that undermine social-ecological resilience in the Great Lakes and elsewhere, and how can we do justice to the volume of effort among science and society to rehabilitate the Great Lakes and create a sustainable future? At the root of this dilemma is a fundamental question that we are obligated to answer: how does our experience stand in relation to our problems? I say that we are obligated because a *burden* is not only a load that must be borne—a serious task for example, with the potential for serious consequences—but it also implies a duty or responsibility.

To grasp the significance of DAAM for accountability and success at solving very real problems facing restoration of the Great Lakes, consider that *all* management decisions are taken in the face of uncertainty (Ludwig et al. (1993), and that *all* key uncertainties in management are learning opportunities (Murray and Marmorek, 2003a). A primary concern is whether the institutional capacity exists (or can be created) to embrace a fundamental and systemically different approach to management that explicitly acknowledges that we always lack sufficient knowledge to act with a full understanding of consequences. DAAM demands that we elevate the role of double-loop learning activities such as monitoring and evaluation beyond the cosmetic and superficial attention they too often receive. The institutionalization of DAAM is dependent on building capacity, support, and enthusiasm for a culture of learning, and systems that enable institutional memory of what is learned. The ability and willingness to institute such a capacity is perhaps the ultimate accountability in considering the question of how to begin to incorporate DAAM into existing or new Great Lakes management paradigms. The present is a good time for those capable of living with uncertainty, suggest Westley et al. (2006) in a hopeful tone, because a willingness to embrace it offers the possibility of transformation, and some relief from the sense of "being stuck" that burdens so much of what environmental management is trying to accomplish.

Literature Cited

Allan C, Curtis A, Stankey G, Shindler B. 2008. Adaptive management and watersheds: a social science perspective. Journal of the American Water Resources Association, 44: 166-174.

Allan C, Stankey G, editors. 2009. Adaptive Environmental Management: A Practioner's Guide. Springer Science and Business Media B.V.

AMET [Adaptive Management Experiment Team]. 2003. Glossary. Accessed 29 Jun 2006 at http://www.ameteam.ca/glossary.html.

Andrews CJ. 2002. Humble Analysis: The Practice of Joint Fact-Finding. Praeger.

ARC [Agreement Review Committee]. 2006. Report to the Great Lakes Binational Executive Committee: Volumes 1, 2, and 3. Accessed 15 Nov 2009 at http://binational.net/glwqa_2007_e.html

Argent RM. 2009. Components of adaptive management. In: Adaptive Environmental Management: A Practioner's Guide. Allan C, Stankey G, editors. pp. 11-32. Springer Science and Business Media B.V.

Argyris C. 1993. On Organizational Learning. Blackwell Business.

Bails J, Beeton A, Bulkley J, DePhilip M, Gannon J, Murray M, Regier H, Scavia D, 2005. Prescription for Great Lakes Ecosystem Protection and Restoration: Avoiding the Tipping Point of Irreversible Changes. Wege Foundation and Joyce Foundation. Accessed 29 Jan 2011 at http://nsgl.gso.uri.edu/michu/michui05009.pdf.

Barr J, Hall TJ, Harris HJ, Krantzberg G, Sowa S. 2010. Review report of the SOLEC independent expert panel. Presented to Environment Canada and the U.S. Environmental Protection Agency. Accessed 30 Nov 2010 at http://msep.mcmaster.ca/epp/publications/SOLEC_Report.pdf.

Benevides H, Davis C, de Leon F, Gilbert R, Jackson J, Nalbone J, Potter J, Stack D, Wilder P. 2007. Promises to Keep, Challenges to Meet. Perspectives from Citizens. Prepared for Alliance for the Great Lakes, Biodiversity Project, Canadian Environmental Law Association, Great Lakes United. Accessed 15 Oct 2010 at http://s.cela.ca/files/uploads/553GLWQA_promises.pdf.

Beratan KK. 2007. A cognition-based view of decision processes in complex social–ecological systems. Ecology and Society, 12.1: art27.

Botts L, Muldoon P. 2005. Evolution of the Great Lakes Water Quality Agreement. Michigan State University Press.

Canada and Ontario. 2007. Canada-Ontario Agreement Respecting the Great Lakes Basin Ecosystem.

Clemen RT, Reilly T. 2001. Making Hard Decisions with DecisionTools®. Duxbury.

Crawford S, Matchett S, Reid K. 2005. Decision Analysis/Adaptive Management (DAAM) for Great Lakes Fisheries: A General Review and Proposal. Draft discussion paper presented to the International Association for Great Lakes Research Conference, Ann Arbor, MI. Accessed 15 Mar 2010 at http://www.uoguelph.ca/~scrawfor.

Crawford S, Wehkamp CA, Smith N. 2010. Translation of Indigenous/Western Science Perspectives on Adaptive Management for Environmental Assessments. Canadian Environmental Assessment Agency, Research and Development Monograph Series. Acccessed 8 Jan 2011 at http://www.ceaa.gc.ca/7F3C6AF0-docs/TIWSPAMEA-eng.pdf.

Cundill G, Fabricius C. 2009. Monitoring in adaptive co-management: toward a learning based approach. Journal of Environmental Management, 90: 3205-3211.

Deriso RB, Marmorek DR, Parnell IJ. 2001. Retrospective patterns of differential mortality and common year-effects experienced by spring and summer chinook salmon (*Oncorhynchus tshawytscha*) of the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences, 58: 2419-2430.

Dewey J, 1920. Reconstruction in Philosophy. Henry Holt and Company.

Folke C, 2006. Resilience: the emergence of a perspective for social-ecological systems analyses. Global Environmental Change, 16: 253-267.

Folke C, Hahn T, Olsson P, Norberg J. 2005. Adaptive governance of social-ecological systems. Annual Review of Environment and Resources, 30: 441-473.

Francis G, Regier HA. 1995. Barriers and bridges to the restoration of the Great Lakes basin ecosystem. In: Barriers and Bridges to the Renewal of Ecosystems and Institutions. Gunderson LH, Holling CS, Light SS, editors. pp. 239-291. Columbia University Press.

GAO [United States General Accounting Office]. 2003. Great Lakes: An Overall Strategy and Indicators for Measuring Progress Are Needed to Better Achieve Restoration Goals. Report GAO-03-515.

GLU [Great Lakes United]. 2010. Governments remain silent on lack of public input. Accessed 19 Dec 2010 at http://www.glu.org/en/press/governments-remain-silent-lack-public-input.

Gregory R, Ohlson D, Arvai J. 2006. Deconstructing adaptive management: criteria for applications to environmental management. Ecological Applications, 16: 2411–2425.

Grumbine RE. 1994. What is ecosystem management? Conservation Biology, 8: 27-38.

Gunderson LH. 2000. Ecological resilience—in theory and application. Annual Review of Ecology and Systematics, 31: 425-439.

Gunderson, LH, Holling CS, editors. 2002. Panarchy: Understanding Transformations in Human and Natural Systems. Island Press.

Gunderson, LH, Holling CS, Light SS, editors. 1995. Barriers and Bridges to the Renewal of Ecosystems and Institutions. Columbia University Press, New York.

Haeseker SL, Jones ML, Peterman RM, Bence JR, Dai W, Christie GC. 2007. Explicit consideration of uncertainty in Great Lakes fisheries management: decision analysis of sea lamprey (*Petromyzon marinus*) control in the St. Marys River. Canadian Journal of Fisheries and Aquatic Sciences, 64:1456-1468.

Hammond JS, Keeney RL, Raiffa H. 1999. Smart Choices: A Practical Guide to Making Better Decisions. Harvard Business School Press.

Hansen GJA, Jones ML. 2008. A rapid assessment approach to prioritizing streams for control of Great Lakes sea lampreys (*Petromyzon marinus*): a case study in adaptive management. Canadian Journal of Fisheries and Aquatic Sciences, 65: 2471-2484.

Hargrove R. 2002. Masterful Coaching. Revised Edition. Jossey-Bass/Pfeiffer.

Hartig JH, Zarull MA. 1992. Keystones for success. In: Under RAPs: Toward Grassroots Ecological Democracy in the Great Lakes Basin. Hartig JH, Zarull MA, editors. pp. 263-279. University of Michigan Press.

Hilborn R, Ludwig D. 1993. The limits of applied ecological research. Ecological Applications, 3: 550-552.

Holling CS. 1973. Resilience and stability of ecological systems. Annual Review of Ecology and Systematics, 4: 1-23.

Holling CS, editor. 1978. Adaptive Environmental Assessment and Management. Wiley.

Holling CS. 1995. What barriers, what bridges? In: Barriers and Bridges to the Renewal of Ecosystems and Institutions. Gunderson LH, Holling CS, Light SS, editors. pp. 3-34. Columbia University Press.

Holling CS. 2001. Understanding the complexity of economic, ecological, and social systems. Ecosystems, 4: 390-405.

Holling CS, Meffe G. 1996. Command and control and the pathology of natural resource management. Conservation Biology, 10: 328-337.

IJC [International Joint Commission]. 2001. Priorities 1999–2001: priorities and progress under the Great Lakes Water Quality Agreement. Science Advisory Board, Chapter 2. Accessed 30 Nov 2010 at http://www.ijc.org/rel/boards/sab/pr9901/index.html.

IJC [International Joint Commission]. 2003a. Priorities 2001–2003: priorities and progress under the Great Lakes Water Quality Agreement. Science Advisory Board, Chapter 5. Accessed 30 Nov 2010 at http://www.ijc.org/php/publications/pdf/ID1568.pdf.

IJC [International Joint Commission]. 2003b. Status of Restoration Activities in Great Lakes Areas of Concern: A Special Report. Accessed 30 Nov 2010 at http://www.ijc.org/php/publications/html/aoc_rep/english/report/pdfs/chapter1-e.pdf.

IJC. [International Joint Commission]. 2009a. Work Group Report on Binational Aquatic Invasive Species Rapid Response Policy Framework, Special Publication 2009-04. Great Lakes Water Quality Agreement Priorities 2007-09 Series. Accessed 22 Feb 2010 at http://meeting.ijc.org/reports.

IJC. [International Joint Commission]. 2009b. Work Group Report on the Nearshore Framework, Special Publication 2009-01. Great Lakes Water Quality Agreement Priorities 2007-09 Series. Accessed 22 Feb 2010 at http://meeting.ijc.org/reports.

IJC. [International Joint Commission]. n.d. International Upper Great Lakes Study. Accessed 8 Jan 2011 at http://www.iugls.org.

Jackson J, Sloan KK. 2008. A Way Forward: Strengthening Decision-Making and Accountability Under the Great Lakes Water Quality Agreement. Accessed 31 Oct 2008 at http://www.glu.org/sites/default/files/Governance%20GLU%20Jan08.pdf.

Johns C. 2005. Transboundary Water Governance: Future Challenges. Report on a Workshop. Royal Society of Canada and McMaster University.

Johnson FA, Moore CT, Kendall WL, Dubovsky JA, Caithamer DF, Kelley JR, Williams BK. 1997. Uncertainty and the management of mallard harvests. Wildlife Management, 61: 202-216.

Jones ML. 1999. Adaptive management and Great Lakes fisheries. In: MacDonald GB, Fraser JZ, Gray P, editors. Adaptive Management Forum: Linking Management and Science to Achieve Ecological Sustainability. Ontario Ministry of Natural Resources, Science Development and Transfer Series No. 001.

Jones ML, Bence JR. 2009. Uncertainty and fishery management in the North American Great Lakes: lessons from applications of decision analysis. In: Pacific Salmon: Ecology and Management of Western Alaska's Populations. Krueger CC, Zimmerman CE, editors. American Fisheries Society.

Jones ML, Bence JR, Szalai EB, Dai W. 2008. Assessing stocking policies for Lake Michigan salmonine fisheries using decision analysis. In: The State of Lake Michigan in 2005. Clapp DF, Horns W, editors. pp. 81-88. Great Lakes Fishery Commission Special Publication 08-02.

Jones M, Nudds T. 2003. Draft Principles of Decision Analysis and Adaptive Management. Prepared for the Saugeen Ojibway/Canada/Ontario Plenary.

Keen M, Brown VA, Dyball R. 2005. Social Learning in Environmental Management: Building a Sustainable Future. Earthscan Publications.

Krantzberg G. 2003. Keeping remedial action plans on target: lessons learned from Collingwood Harbour. Journal of Great Lakes Research, 29: 641-51.

Krantzberg G. 2006. Sustaining the gains made in ecological restoration: case study Collingwood Harbour, Ontario. Environment, Development and Sustainability, 8: 413-424.

Krantzberg G. 2009. Renegotiating the Great Lakes Water Quality Agreement: the process for a sustainable outcome. Sustainability 1: 254-67.

Lancia RA, Braun CE, Collopy MW, Dueser RD, Kie JG, Martinka CJ, Nicol JD, Nudds TD, Porath WR, Tilghman NG. 1996. ARM! for the future: adaptive resource management in the wildlife profession. Wildlife Society Bulletin, 24: 436-442.

Lancia, RA, Nudds TD, Morrison ML. 1993. Adaptive resource management: policy as hypothesis, management by experiment. Opening comments: slaying slippery shibboleths. Transactions of the North American Wildlife Natural Resources Conference (Washington D.C., 19-24 Mar 1993), 58: 505-508.

Lebel L, Anderies JM, Campbell B, Folke C, Hatfield-Dodds S, Hughes TP, Wilson J. 2006. Governance and the capacity to manage resilience in regional social-ecological systems. Ecology and Society, 11.1: art19.

Lee KN. 1993. Compass and Gyroscope: Integrating Science and Politics for the Environment. Island Press.

Lee KN. 1999. Appraising adaptive management. Conservation Ecology, 3.2: art3.

Lee W. 1971. Decision Theory and Human Behaviour. John Wiley & Sons.

Leopold, A. 1930. The American game policy in a nutshell. Transactions of the 17th American Game Conference, 281-283.

Lindley DV. 2006. Understanding Uncertainty. Wiley Interscience.

Linkov I, Satterstrom FK, Kiker G, Batchelor C, Bridges T, Ferguson E. 2006. From comparative risk assessment to multi-criteria decision analysis and adaptive management: recent developments and applications. Environment International, 32: 1072-1093.

Lubell M, Leach WD, Sabatier PA. 2009. Collaborative watershed partnerships in the epoch of sustainability. In: Toward Sustainable Communities: Transition and Transformations in Environmental Policy. Second edition. Mazmanian DA, Kraft ME, editors. pp. 255-288. MIT Press.

Ludwig D, Hilborn R, Walters C. 1993. Uncertainty, resource exploitation, and conservation: lessons from history. Science, 260: 17, 36.

Ludwig D, Mangel M, Haddad B. 2001. Ecology, conservation, and public policy. Annual Review of Ecology and Systematics, 32: 481-517.

MA [Millennium Ecosystem Assessment]. 2005. Ecosystems and Human Well-being: Synthesis. Island Press.

MacDonagh-Dumler J. 2009. Policy innovation for Great Lakes ecosystem management. Journal of Great Lakes Research, 35: 477-481.

MacDonald GB, Fraser JZ, Gray P, editors. 1999. Adaptive Management Forum: Linking Management and Science to Achieve Ecological Sustainability. Ontario Ministry of Natural Resources, Science Development and Transfer Series No. 001.

Manno J, Krantzberg G. 2008. Rediscovering and revitalizing the Great Lakes governance. In: Governance for Sustainability: Issues, Challenges, Successes. Bosselmann K, Engel R, Taylor P, editors. pp. 159-170. IUCN Environmental Policy and Law Paper No. 70.

Marmorek D, Peters C. 2002. Finding a PATH toward scientific collaboration: insights from the Columbia River basin. Conservation Ecology, 5.2: art8.

Mazmanian DA, Kraft ME. 2009. The three epochs of the environmental movement. In: Toward Sustainable Communities: Transition and Transformations in Environmental Policy. Second edition. Mazmanian DA, Kraft ME, editors. pp. 3-32. MIT Press.

McDaniels TL, Gregory R. 2004. Learning as an objective within a structured risk management decision process. Environmental Science & Technology, 38: 1921-1926.

McLaughlin C, Krantzberg G. 2006. Toward a 'better understanding' of the Great Lakes Basin Ecosystem. Journal of Great Lakes Research 32, 197-199.

Meadows DH. 2008. Thinking in Systems: A Primer. Chelsea Green Publishing.

Miles Jr. RF. 2007. The emergence of decision analysis. In: Advances in Decision Analysis: From Foundations to Applications. Edwards W, Miles Jr. RF, von Winterfelt D, editors. pp. 13-31. Cambridge University Press.

Miller A. 1999. Environmental Problem Solving: Psychosocial Barriers to Adaptive Change. Springer.

Miller C. 2001. Hybrid management: boundary organizations, science policy, and environmental governance in the climate regime. Science, Technology, and Human Values, 26: 478-500.

Moran EF. 2010. Environmental Social Science: Human-Environment Interactions and Sustainability. Wiley-Blackwell.

Murray C, Marmorek DR. 2003a. Adaptive management and ecological restoration. In: Ecological Restoration of Southwestern Ponderosa Pine Forests. Freiderici P, editor. pp. 417-428. Island Press.

Murray C, Marmorek DR. 2003b. Adaptive management: A science-based approach to managing ecosystems in the face of uncertainty. Prepared for presentation at the Fifth International Conference on Science and Management of Protected Areas: Making Ecosystem Based Management Work, Victoria, British Columbia, May 11-16, 2003.

Norberg J, Cumming GS, editors. 2008. Complexity Theory for a Sustainable Future. Columbia University Press.

Norton BG. 1995. Evaluating ecosystem states: two competing paradigms. Ecological Economics, 14: 113-127.

Nudds TD. 1999. Adaptive management and the conservation of biodiversity. In: Practical Approaches to the Conservation of Biological Diversity. Baydack RK, Campa III H, Haufler JB, editors. pp.179-193, 288-291. Island Press.

Nudds TD, Jiao Y, Crawford S, Reid K, McCann K, Yang W. 2003. Decision Analysis and Adaptive Management (DAAM) Systems for Great Lakes Fisheries: The Lake Erie Wall-eye and Yellow Perch Fisheries: Project Background and Work Plan. Prepared for the Ontario Commercial Fisheries Association and the Chippewas of Nawash First Nation.

OAG [Office of the Auditor General of Canada]. 2001. A legacy worth protecting: charting a sustainable course in the Great Lakes and St. Lawrence River basin; Chapter 1 of the Report of the Commissioner of the Environment and Sustainable Development. Public Works and Government Services Canada.

Ohlson DW. 1999. Exploring the Application of Adaptive Management and Decision Analysis to Integrated Watershed Management. M.Sc. Thesis, University of British Columbia.

Pahl-Wostl C. 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. Global Environmental Change, 19: 354-365.

Parson EA, Clark WC. Sustainable development as social learning: theoretical perspectives and practical challenges for the design of a research program. In: Barriers and Bridges to the Renewal of Ecosystems and Institutions. Gunderson LH, Holling CS, Light SS, editors. pp. 428-460. Columbia University Press.

Payne JW, Bettman JR, Johnson EJ. 1993. The Adaptive Decisionmaker. Cambridge University Press.

Peterman R, Anderson JL. 1999. Decision analysis: a method for taking uncertainties into account in risk-based decision-making. Human and Ecological Risk Assessment, 5: 231-244.

Peterman R, Peters CN. 1998. Decision analysis: taking uncertainties into account in forest resource management. In: Statistical Methods for Adaptive Management Studies (Handbook No. 42.). Sit V, Taylor B, editors. pp. 105-127. British Columbia Ministry of Forestry.

Peters CN, Marmorek DR, Deriso DB. 2001. Application of decision analysis to evaluate recovery actions for threatened Snake River fall chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences, 58: 2447-2458.

Raiffa H. 1968. Decision Analysis: Introductory Lectures on Choices Under Uncertainty. Addison-Wesley.

Regier HA, Jones ML, Addis J, Donahue M. 1999. Great Lakes–St. Lawrence River basin assessments. In: Bioregional Assessments: Science at the Crossroads of Management and Policy. Johnson KN, Swanson FJ, Herring M Greene S, editors. pp. 133-165. Island Press.

Sabatier, PA. 1993. Policy change over a decade or more. In: Policy Change and Learning: An Advocacy Coalition Approach. Sabatier PA, Jenkings-Smith HC, editors. pp. 13-39. Westview Press.

Sainsbury KJ, Campbell RA, Lindholm R, Whitelaw AW. 1997. Experimental management of an Australian multispecies fishery: examining the possibility of trawl induced habitat modifications. In: Global Trends: Fisheries Management. Pikitch EL, Huppert DD Sissenwine MP, editors. pp. 107- 112. American Fisheries Society Symposium, Vol. 20.

Sainsbury KJ, Campbell RA, Whitelaw AW. 1993. Effects of trawling on the marine habitat on the north west shelf of Australia and implications for sustainable fisheries management. In: Sustainable Fisheries Through Sustaining Fish Habitat. Hancook DA, editor. pp. 137-145. Australian Government Publishing Service.

Sainsbury KJ. 1987. Assessment and management of the demersal fishery on the continental shelf of northwestern Australia. In: Tropical Snappers and Groupers: Biology and Fisheries Management. Polovina JJ, Ralston S, editors. pp. 465-503. Westview Press.

Sainsbury KJ. 1988. The ecological basis of multispecies fisheries and management of a demersal fishery. In: Fish Population Dynamics. Second edition. Gulland JA, editor. pp. 349-382. Wiley.

Sainsbury KJ. 1991. Application of an experimental approach to management of a tropical fishery with highly uncertain dynamics. ICES Journal of Marine Science, 193: 301-320.

Schleen LP, Christie GC, Heinrich JW, Bergstedt RA, Young RJ, Morse TJ, Lavis DS, Bills TD, Johnson JE, Ebener MP. 2003. Development and implementation of an integrated program for control of sea lampreys in the St. Marys River. Journal of Great Lakes Research, 29.s1: 677-693.

Scholz JT, Stiftel B. 2005. Introduction: the challenges of adaptive governance. In: Adaptive Governance and Water Conflict: New Institutions for Collaborative Planning. Scholz JT, Stiftel B, editors. pp. 1-11. Resources for the Future.

Schreiber ESG, Bearlin AR, Nicol SJ, Taylor CR. 2004. Adaptive management: a synthesis of current understanding and effective application. Ecological Management and Restoration, 5: 177-182.

Simon H. 1957. Models of Man. Wiley.

Simon H. 1972. Theories of bounded rationality. In: Decision and Organization. McGuire CB, Radner R, editors. pp. 161-176. North-Holland Publishing Company.

Sit V, Taylor B, editors. 1998. Statistical Methods for Adaptive Management Studies. British Columbia Ministry of Forests, Research Branch, Land Management Handbook No. 42.

Sproule-Jones M. 2002. Restoration of the Great Lakes: Promises, Practices, Performances. UBC Press.

Stolnack SA, Bryant MD, Wissmar RC. 2005. A review of protocols for monitoring streams and juvenile fish in forested regions of the Pacific Northwest. General Technical Report PNW-GTR-625. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Susskind L, Field P, van der Wansem M, Peyser J. 2007. Integrating scientific information, stakeholder interests, and political concerns. In: Integrated Resource and Environmental Management: Concepts and Practice. Hanna KS, Slocombe DS, editors. pp. 181-203. Oxford University Press.

Walters, C.J. 1986. Adaptive Management of Renewable Resources. MacMillan.

Walters CJ. 2007. Is adaptive management helping to solve fisheries problems? Ambio, 36: 304-307.

Walters CJ, Green R. 1997. Valuation of experimental management options for ecological systems. Journal of Wildlife Management, 61: 987-1006.

Walters C, Gunderson LH, Holling CS. 1992. Experimental policies for water management in the everglades. Ecological Applications, 2: 189-202.

Waltner-Toews D, Kay JJ, Lister N-ME, editors. 2008. The Ecosystem Approach: Complexity, Uncertainty, and Managing for Sustainability. Columbia University Press.

Wenger E, McDermott R, Snyder W. 2002. Cultivating Communities of Practice: A Guide to Managing Knowledge. Harvard Business School Press.

Westley F. 1995. Governing design: the management of social systems and ecosystems management. In: Barriers and Bridges to the Renewal of Ecosystems and Institutions. Gunderson LH, Holling CS, Light SS, editors. pp. 391-427. Columbia University Press.

Westley F, Zimmerman B, Patton MQ. 2006. Getting to Maybe: How the World is Changed. Random House Canada.

Williams BK, Johnson FA. 1995. Adaptive management and the regulation of waterfowl harvests. Wildlife Society Bulletin, 23: 430-436.

Williams BK, Johnson FA, Wilkins K. 1996. Uncertainty and the adaptive management of waterfowl harvests. Journal of Wildlife Management, 60: 223-232.

Williams BK, Szaro RC, Shapiro DD. 2009. Adaptive Management: The U.S. Department of the Interior Technical Guide (Revised Edition). Adaptive Management Working Group, U.S. Department of the Interior. Accessed 15 October 2010 at http://www.doi.gov/initiatives/AdaptiveManagement/documents.html.

Wondolleck JM, Yaffee LS. 2000. Making Collaboration Work: Lessons From Innovation in Natural Resource Management. Island Press.

REMEDIES FOR IMPROVED DEVELOPMENT AND IMPLEMENTATION OF REMEDIAL ACTION PLANS IN THE GREAT LAKES: A POLICY DELPHI STUDY[9]

> There is no discipline in the world so severe as the discipline of experience subjected to the tests of intelligent development and direction.
>
> —John Dewey, 1938
> *Experience and Education*

Abstract

Remedial Action Plans have been the principal program to operationalize the ecosystem approach to management in the Great Lakes. Progress since 1987 has been slow and disappointing, however. It is possible that the program may be terminated or be subsumed into a new framework for addressing chronic environmental degradation in nearshore areas despite very little systematic inspection of the strengths and limitations of the RAP program. We conducted a three-round online and anonymous Policy Delphi involving several dozen experts in the development and implementation of RAPs across the Great Lakes basin within government, industry, academia, and civil society. Round 1 collected their direct knowledge of the strengths and limitations of RAPs. We distilled that feedback in Round 2 to have participants further reflect specifically on what worked and what did not work in their RAP experience as practitioners. We found an expected diversity of opinion on what ails the RAP program, and an unexpected consensus on the desire to move forward with all of the seven governance options that emerged from Round 2 and were ranked in Round 3. The ranking also indicated a consensus that the options were relatively feasible and likely to succeed as enhancements to the current governance of RAPs. Importantly, the results relate to both the structure and attributes of RAP governance. We stress the need to focus on the predominant tendencies and characteristic attitudes that underlie RAP processes. These findings will have broad significance for other evolving place-based nearshore restoration strategies in the Great Lakes and elsewhere that such programs have been initiated.

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[9] McLaughlin C, Krantzberg G. *In prep.* Remedies for Improved Development and Implementation of Remedial Action Plans in the Great Lakes: A Policy Delphi Study.

Keywords

Great Lakes Water Quality Agreement; Annex 2; Remedial Action Plans; development and implementation; strengths and limitations; Policy Delphi; governance options; institutional disposition

Introduction

Amendments to the Great Lakes Water Quality Agreement in a 1987 Protocol designated forty-two of the most severely degraded areas in the region as Areas of Concern (AOCs; Figure 2; a forty-third AOC was added in 1991). Each AOC is located in nearshore environments such as embayments, harbours, and connecting channels, and the degradation of each is defined by the measurable 'impairment' of numerous chemical, physical, or biological aspects of the water body termed 'beneficial uses' (Table 2). Many beneficial use impairments (BUI) are strictly ecological, such as *fish tumours or other deformities*, and *loss of fish and wildlife habitat*. Others have socioeconomic repercussions such as *restrictions on fish and wildlife consumption* and *restrictions on dredging activities*. Although many are measurable using technical means, human preferences in some are explicit, such as *degradation of aesthetics* and *taste and odor problems*. However, the satisfactory endpoint objectives of every impairment extend beyond the purview of strict technical analysis, at least implicitly, because conflicts over the management of such common pool resources are never simply material (Adams et al., 2003), and social and cultural norms vary among individuals and sectors. Difficulty is therefore expected in deriving collective decisions on questions such as whether to restore wildlife habitat prior to visual aesthetics, for example, as well as determining how much habitat is enough or when and whether sediment remediation is sufficient. Although these questions can be informed by science, their resolution as policy issues is a sociopolitical exercise.

The 1987 amendments formalized Remedial Action Plans (RAPs) as locally-designed ecosystem approaches to the removal of beneficial use impairments (BUIs). Annex 2 of the Agreement stipulates that RAPs are to "embody a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses" in AOCs, and that they are to provide a continuing historical record of assessment, remedial actions, and changes in the environmental conditions of AOCs that result from such actions. The ecosystem approach represents a significant departure from the traditional approach of the original 1972 Agreement, and demonstrates why the Agreement's ability to evolve to meet new challenges has been considered pioneering (Vallentyne and Beeton, 1988; Botts and Muldoon, 2005). Initial success of the 1972 Agreement was based on a rational analytic understanding of contamination problems as well documented (to the extent that they were known) and technical solutions as relatively straightforward (Bulkley et al., 1989; Regier et al., 1999).

FIGURE 5. Locations of 43 Areas of Concern in the Great Lakes – St. Lawrence River Basin. Map courtesy of Environment Canada; note that Wheatley Harbour in Ontario was delisted in April, 2010, although an updated map was unavailable when the thesis went to print.

Areas of Concern in the Great Lakes - St. Lawrence River Basin
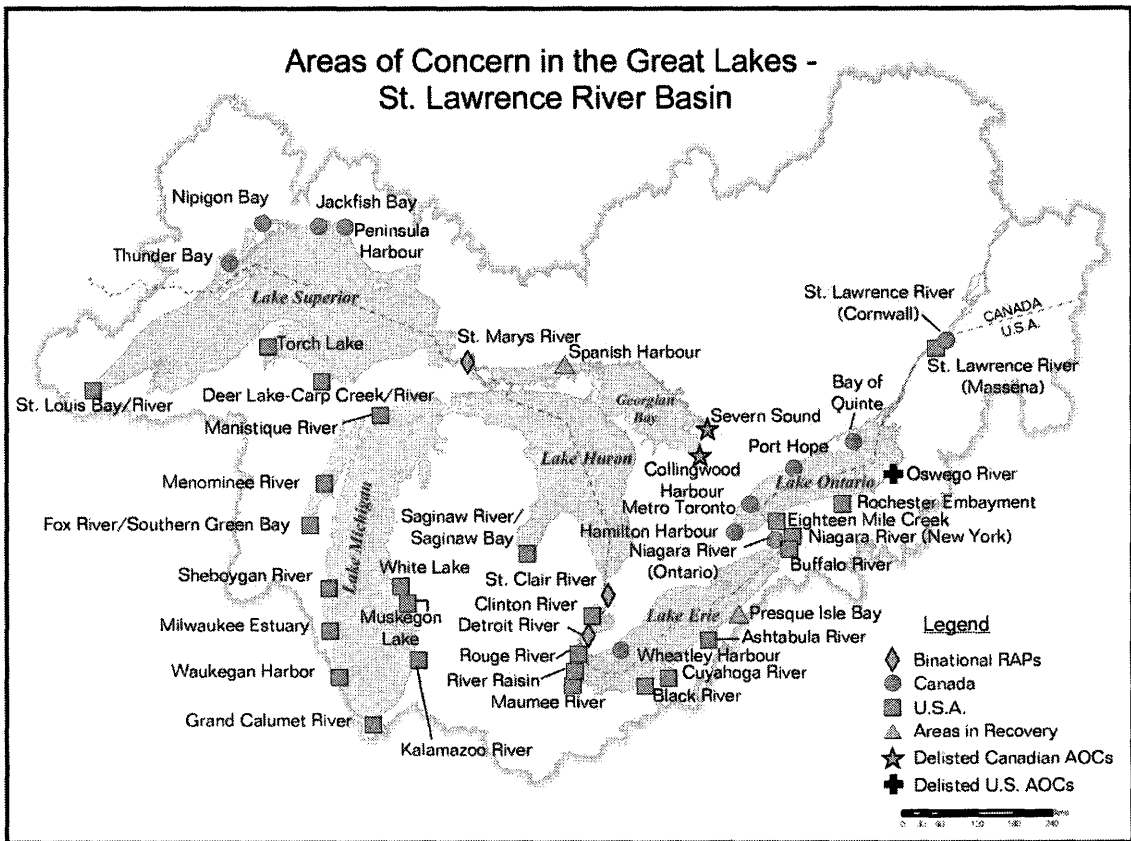
TABLE 2. Beneficial Use Impairments. Impairment of a beneficial use (BUI) of the Great Lakes is defined as a change in the chemical, physical, or biological integrity of the Great Lakes system sufficient to cause any of the 14 use impairments listed below, or other related uses covered by Article IV of the Great Lakes Water Quality Agreement, such as the microbial objective for waters used for body contact recreational activities. The figures in the table (n = 39) do not include the four Areas of Concern (AOC) delisted to date: Collingwood Harbour, Severn Sound, and Wheatley Harbour in Ontario, and Oswego River in New York.

	Beneficial Use Impairment	Number of AOCs with with BUI	Percentage of AOCs with BUI
1.	restrictions on fish and wildlife consumption	34	87
2.	tainting of fish and wildlife flavour	4	10
3.	degradation of fish and wildlife populations	27	69
4.	fish tumours or other deformities	20	49
5.	bird or animal deformities or reproductive problems	13	33
6.	degradation of benthos	34	83
7.	restrictions on dredging activities	34	87
8.	eutrophication or undesirable algae	19	49
9.	restrictions on drinking water consumption, taste and odor problems	12	29
10.	beach closings	24	59
11.	degradation of aesthetics	24	59
12.	added costs to agriculture or industry	7	17
13.	degradation of phytoplankton and zooplankton populations	9	22
14.	loss of fish and wildlife habitat	31	79

Such success was typical of the traditional technocratic approach to environmental problem solving that assumes primacy for technical information and the role of the technological expert (Miller, 1985). The phosphorus abatement program initiated by the first Agreement led directly to water quality improvement (although to a lesser extent than was first expected; IJC, 1976). Significant new threats to human and ecosystem health from persistent bioaccumulative chemicals were detected during the mid 1970s, however, with a corresponding recognition that a more comprehensive approach to management would be required (NRC-RSC, 1985). Subsequently, the revised 1978 Agreement dramatically altered the conceptual basis for restoration in an attempt to better understand and relate to degrading social-ecological interactions and correct them with new and more comprehensive programs (Lee et al., 1982; Caldwell, 1988). In introducing the concept of RAPs, the 1987 Protocol provided a mechanism by which the local character and variation in problems and possible solutions could be reflected in management. RAPs also extended participation in planning to all levels of government, industry and other private interests, civil society and aboriginal groups, and academics and individual citizens.

The RAP process involves identification of BUIs and their causes, options and preferred actions to resolve these impairments that identify the persons or agencies responsible for implementation of remedial measures, a schedule for implementation, and an evaluation process for surveillance and monitoring to track progress and confirm eventually that the impairments have been ameliorated. The end goal of a RAP is 'delisting' of the AOC, meaning that all BUIs identified have been restored according to defined criteria through a process that engages the complete range of stakeholders and secures a commitment for full implementation (Botts and Muldoon, 2005). At the outset, RAPs generated excitement and optimism from three principal sources: the explicit inclusion of multiple and non-technical stakeholders in decision making, the accountability involved in specifying responsibilities for action, and the oversight function of the IJC to review and evaluate progress towards the objectives of each RAP (Hartig and Vallentyne, 1989). And yet, "slow progress" on RAPs was a "major disappointment almost from the beginning" (Botts and Muldoon, 2005). For example, Colborn et al. (1990) stated that RAPs would be a "major test of the ecosystem approach," and that the 1990s would be a "crucial period," the partial or complete withdrawal of federal or subnational funding for RAPs in both countries during that decade contributed to a lack of implementation and a loss of public enthusiasm (IJC, 2003; Krantzberg, 2002, 2003; Botts and Muldoon, 2005; OPAC, 2006). These circumstances were exacerbated by a decline in the effectiveness of IJC oversight (Botts and Muldoon, 2005) and a general leadership malaise characterized in part by a governmental "reluctance" to accept responsibility for fulfilling Agreement obligations (GAO, 2003; also OAG, 2001; GAO, 2009).

There was significant effort during the first decade of RAPs to determine the key characteristics that would promote their success (e.g., Caldwell, 1988; Hartig and Thomas, 1988; Hartig and Vallentyne, 1989; Hartig and Zarull, 1992b; Landre and Knuth, 1993; MacKenzie, 1993, 1997; Gurtner-Zimmerman, 1995; Hartig et al., 1995; Krantzberg and Houghton, 1996; Kellogg, 1998; Krantzberg, 1998). But a Web of Science literature search for more recent insights on RAPs demonstrates a precipitous decline in interest in RAP evaluation during the second (and now third) decade of the RAP program (notwithstanding e.g., Sproule-Jones, 2002). The most recent IJC (2003) status report on progress in RAP development and implementation and the restoration of beneficial uses concluded that key challenges to further progress include insufficient financial commitments, unclear accountability and responsibility, undefined restoration priorities and targets, and a lack of adequate monitoring—essentially the entire program. More recently, independent federal auditing agencies have been critical of the inability of both federal governments to adequately coordinate and assess AOC-related activities and outcomes (e.g., OAG, 2008; GAO, 2009). And more broadly, the formal 2006-2007 Agreement Review concluded that many of the Agreement's provisions are outdated, the roles of various orders of government and the public are not clear, and accountability is weak (ARC, 2007). Jackson (2010) observes that with only four of the forty-three AOCs currently delisted there are now frequent calls for the AOC concept and the RAP program to be abandoned. In this context, the IJC (2009) has recently proposed the development of a framework to more broadly encompass the ecological problems that occur in the nearshore of the Great Lakes and link those problems more closely to watershed management initiatives. But what is current reality with respect to those three initial sources of enthusiasm for RAPs? Understanding such critical collaborative interactions is a key to successful management planning and effective decision making (Bulkley et al. 1989), and could inform new approaches to RAPs and other policy developments specific to the nearshore zone of the Great Lakes and their connecting waterways.

Deficiencies in governance will have unknown consequences for RAPs into the future. The slow progress may result in a gradual, incremental program retreat, in program termination, in RAPs being be subsumed into a broader governance framework, or evolving in some combination of these options. Given this uncertainty and the potential for significant changes in the RAP program, it is an appropriate time to look back at what has worked, or not, and why. Yet a formal post-audit appraisal with respect to the RAP program's development and implementation appears non-evident. It is common for authorities to announce and instigate new natural resource management programs without evaluating the effectiveness of current or previous programs. Such institutional behaviour is symptomatic of a pathology of natural resource management that stifles learning from experience and diminishes the resilience of social-ecological systems (Holling, 1995; Holling and Meffe, 1996; Briggs, 2003). We sought to help

overcome this tendency with respect to RAPs. To fully benefit from experiences with the RAP program in a forward-looking, solution-based manner, we conducted a study that accessed the knowledge base of a cross section of technical and non-technical experts inside and outside of government with significant first-hand experience with RAP development and/or implementation. The goal of this study was to use an analysis of factors that helped or hindered the success of the development and implementation of RAPs to distil a set of lessons learned from that collective knowledge. And secondly, to translate those lessons into policy options that could inform the future design of placed-based, nearshore restoration commitments and governance.
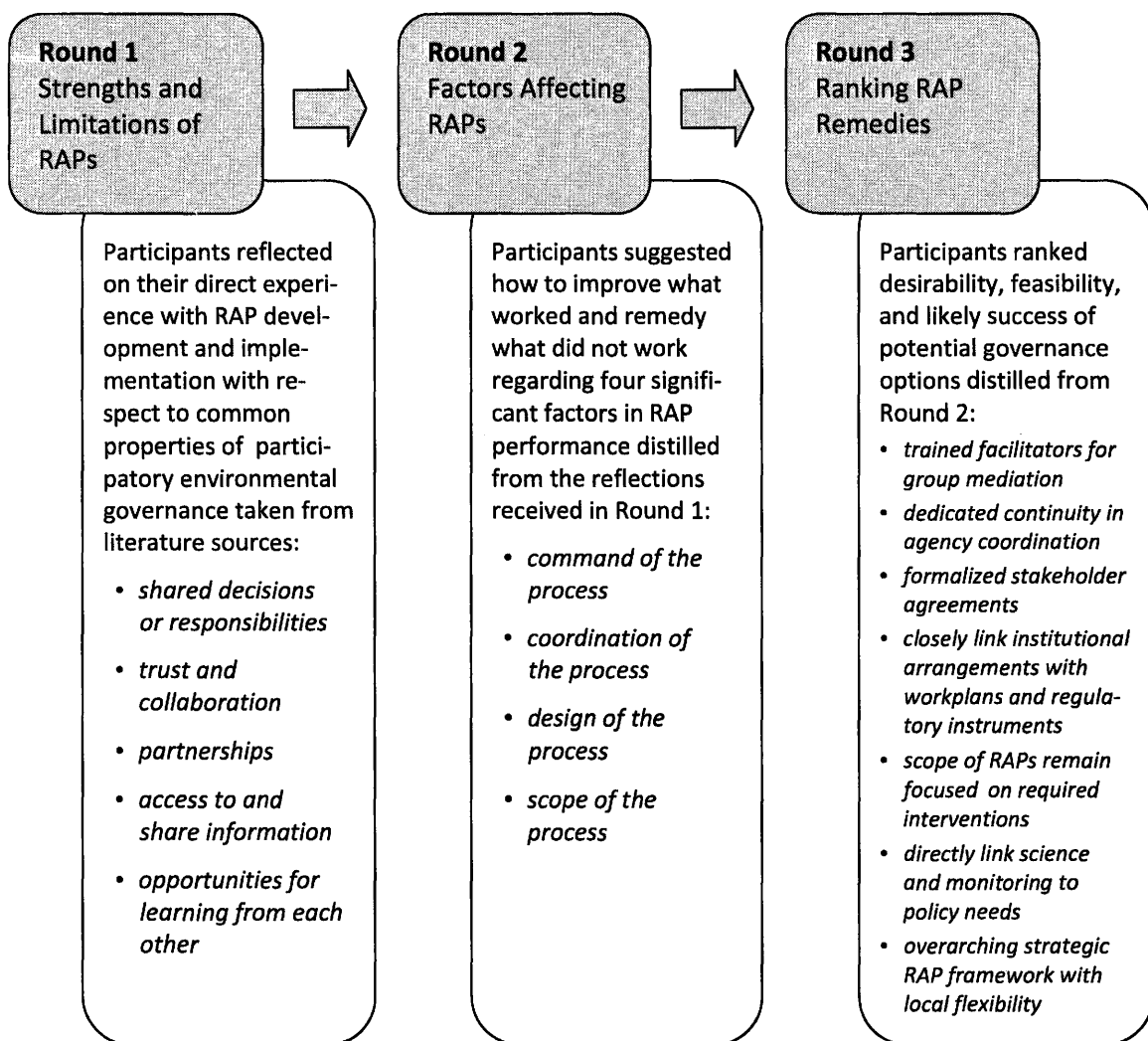
Methods

We used the Policy Delphi technique to systematically characterize the strengths and limitations of RAP development and implementation in order to distil broad expert knowledge from across the Great Lakes basin into policy options to facilitate decisions on future governance reform for improved place-based restoration of nearshore environments (Figure 6).

The Delphi qualitative research technique was initially devised to make effective use of informed intuitive judgment to generate long-range consensual forecasts on technological issues (Dalkey and Helmer, 1963). In its simplest form, the technique is a systematic solicitation and collation of anonymous expert opinion through a series of designed questionnaires ('rounds') interspersed with structured feedback (Linstone and Turoff, 1975). Its iterative nature allows participants to reflect on that feedback prior to providing subsequent opinion, and therefore in a sense 'collaborate' with other participants. Achieving a consensus around a question, proposal, or forecast is the traditional objective of a Delphi study, and convergence of opinion remains an objective of most standard Delphi applications (Landeta, 2006). Where a systematic, open, and accurate collection of opinion is required, the absence of personal contact among participants in a Delphi is advantageous over workshops and other interacting group techniques that can suffer from individual dominance due to rank or personality, as well as inherent pressure to conform to group opinion (Needham and de Loë, 1990). In addition, the Delphi generally demonstrates a high level of participant equality through the anonymous pooling of independent judgments and opinions.

The conventional Delphi assumes that a choice can be justified prior to its presentation to decision makers for formal approval. This suggests that the conventional Delphi is inappropriate for policy questions, as the product is not consensus necessarily, but rather a comprehensive assessment of relevant options and their rationales or some other measure of their suitability (Needham and de Loë, 1990). Inherent dissensus is to be expected in an exploration of complex policy issues, however, and we therefore designed our study using the Policy Delphi survey methodology, a variation of the standard Delphi, as a forum for ideas designed to generate the

FIGURE 6. Schematic of the Three-Round Policy Delphi Study. The figure illustrates the flow of events in the process of distilling potential governance options from the direct experience and substantive knowledge of our participant group in the development and/or implementation of RAPs. Round 1 collected open-ended reflections on strengths and limitations of each local RAP governance model framed by properties of governance of interest in Great Lakes governance design. Round 2 was based on four significant factors in RAP performance distilled using qualitative coding methods from the textual data gathered in Round 1; it invited open-ended suggestions on how to improve what worked and remedy what did not work with respect to the influence of those four factors on the RAP experience of each participant. Round 3 was based on seven potential governance options distilled from improvements and remedies suggested in Round 2. Participants rank each option based on their belief in its desirability (i.e., is it advisable and worthwhile pursuing), feasibility (i.e., would there be receptivity to considering and supporting the idea), and likelihood for success (i.e., would there be positive governance and environmental performance outcomes if the idea were implemented).

Round 1
Strengths and Limitations of RAPs

Participants reflected on their direct experience with RAP development and implementation with respect to common properties of participatory environmental governance taken from literature sources:

- shared decisions or responsibilities
- trust and collaboration
- partnerships
- access to and share information
- opportunities for learning from each other

Round 2
Factors Affecting RAPs

Participants suggested how to improve what worked and remedy what did not work regarding four significant factors in RAP performance distilled from the reflections received in Round 1:

- command of the process
- coordination of the process
- design of the process
- scope of the process

Round 3
Ranking RAP Remedies

Participants ranked desirability, feasibility, and likely success of potential governance options distilled from Round 2:

- trained facilitators for group mediation
- dedicated continuity in agency coordination
- formalized stakeholder agreements
- closely link institutional arrangements with workplans and regulatory instruments
- scope of RAPs remain focused on required interventions
- directly link science and monitoring to policy needs
- overarching strategic RAP framework with local flexibility

fullest and most substantive range of views and potential resolutions to a policy issue (Turoff, 1970, 1975; de Loë, 1995; Franklin and Hart, 2007). The Policy Delphi is a decision-facilitation tool used to address a broadening set of objectives, such as to explore or expose underlying assumptions or perceptions (e.g., Collins et al., 2009), to perform a post-hoc policy implementation analysis (e.g., Buck et al., 1993), and to determine or develop a range of possible strategic options or priorities (e.g., de Loë, 1995). The objectives and outcomes of our study aligned with each of these uses of the Policy Delphi technique, which are each intended to embed a *breadth* of expertise throughout the research process (Gabb et al., 2006; original emphasis). As the RAP program has received so little formal inspection, the Policy Delphi allowed us to organize very broad and well-informed conjecture into a systematic knowledge base to determine empirically the strengths and limitations of RAPs, and to shape governance options for future consideration (Lubell et al., 2005).

Participants

Participants were invited from Ontario and U.S. Great Lakes states (i.e., New York, Pennsylvania, Ohio, Michigan, Indiana, Illinois, Wisconsin, and Minnesota) via email that included an overview of the proposed study and its rationale. Each invitee was an expert in the development and/or implementation of RAPs from government, industry, academia, and civil society. An expert with respect to a Policy Delphi study is anyone deemed to have special knowledge based on experience with the issue or problem domain being examined. In our study, expert participants were individual stakeholders or representatives of stakeholder groups with direct and substantive experience in the development and/or implementation of RAPs. Invitees were selected based on the knowledge of the researchers (i.e., we knew from our own experience that the invitee fit the description of an expert in this study), RAP documents listing the identity of those with the type of experience fitting the description of an expert in this study, and the suggestions of other invited experts where the person suggested also fit the description of an expert in this study. We endeavoured to invite a group that was both broadly representative of the multiple jurisdictional and sectoral categories identified, and manageable within the construct of the methodology. We used the online survey service SurveyMonkey to facilitate data gathering; data storage and statistical analyses were performed using Microsoft Excel. Participation was anonymous and the identity of participants was hidden from all involved, including the researchers, in order that participants could feel free to share their knowledge and opinions without reservation. Due to this anonymity we had no way of tracking individuals across rounds. Broad categorical data were requested that would identify the citizenship and sectoral affiliations of each participant, but no information was requested or collected that could identify an individual. Group A invitees (i.e., those invited to participate in all rounds) could participate in

any one or more of the rounds, and their participation in a particular round was not contingent on their participation in any other round.

Round 1, Strengths and Limitations of RAPs

Round 1 asked four open-ended questions (regarding both RAP development and implementation) in order to generate textual data describing characteristic strengths and limitations of RAPs as a governance process experienced by the expert participants. The four themes listed below framed Round 1 and were broadly representative of principal topics of consideration in published research on the RAP program (e.g., Hartig and Law, 1994), collaborative management (e.g., Sabatier et al., 2005; Plummer and Armitage, 2007a, 2007b), publications of the IJC (e.g., IJC, 2006a, 2006b), and recent public discussions regarding the future of Annex 2, particularly RAPs (e.g., ARC, 2007). Participants were asked to comment on the strengths and limitations of RAP development and implementation, in their own experience, as governance processes to:

1. Collaborate and share responsibility for management and/or decisions.
2. Build partnerships and trust.
3. Provide access to and share information.
4. Provide opportunities for learning from each other.

Round 2, Affective Factors

Guided by qualitative techniques for the analytical categorization of textual data, we applied a structural coding procedure to the combined contributions (6931 words in 218 responses) of Round 1 (Saldaña, 2009; also Richards 2009). Structural coding applies a content-based conceptual phrase representing a topic of inquiry to a segment of text that relates to a specific research question used to initiate and frame the response (Saldaña, 2009). Using this process we generated 17 unique representative codes. In order to move forward, we eliminated from consideration in the analysis those codes that were exceptionally consensual, or would not translate easily into 'actionable' items with which ongoing Great Lakes policy reform processes could embrace. We selected four code types that occurred widely for both development and implementation, that varied widely in the direction (e.g., positive or negative) and magnitude (e.g., mild or emphatic) of the responses, and that we deemed would be 'actionable' within the Great Lakes policy regime. Invitees were asked to suggest improvements to what worked or remedies for what did not work with respect to the following four significant determinants of RAP program outcomes:

1. *Command of the process*, referring to the control of the process; to direct, guide, lead, manage, and be in charge of the process; to provide a mandate and an atmosphere that

encourages and validates participation; to take and share responsibility for decisions and direction.

2. *Coordination of the process*, referring to mechanisms to organize, facilitate or integrate, as in people, activities, information, research, expertise, and ideas.

3. *Design of the process*, referring to characteristics of institutional approaches, arrangements, contexts, structures, models, or frameworks; including specifics such as rules, work plans, documentation, and monitoring; and including qualities such as consistency and openness.

4. *Scope of the process*, referring to the extent or range of points of view, issues under consideration, and operations, particularly with respect to ideas, objectives, and the mandate of the process.

Round Three, Ranking Remedies

Again we applied a structural coding procedure to the combined contributions (2849 words in 94 responses) of Round 2 (Saldaña, 2009; also Richards 2009). Using this process we generated seven categorizations of expert suggestions on how to improve what worked and how to remedy what did not work with respect to RAP development and implementation. These seven categories were phrased in the form of seven potential 'actionable' policy options:

1. Ensure government coordination involves senior personnel trained and experienced in the mediation of group processes and able to navigate political arenas.

2. Ensure continuity of government coordination (meaning that coordination roles do not go unfilled for long periods of time, and that those roles are assigned adequate and dedicated time).

3. Create stakeholder agreements and implementation workplans with assigned responsibilities, timetables, deliverables, and explicit criteria for engaging new stakeholders, ideas, and issues.

4. More closely link institutional arrangements and workplans to legislative and regulatory instruments.

5. Require delisting endpoints that reflect environmental quality to ensure that the scope of RAPs remain focused on required interventions.

6. Directly link science and monitoring to policy needs regarding restoration of beneficial uses.

7. Provide an overarching strategic RAP development and implementation framework that enables local flexibility.

Participants were asked to rank the desirability, feasibility, and likelihood for success of each option using a 7-point Likert scale. The scale permitted ratings of individual belief as *highly*, *very*, or *somewhat* desirable, feasible, or likely (and that we assigned 7, 6, or 5 respectively) or *highly*,

very, or *somewhat* undesirable, unfeasible, or unlikely (and that we assigned 1, 2, or 3 respectively). A rank of 4 was permitted and was explained to mean that the participant thought the idea had merit but declined to suggest the direction of their belief. A *desirable* idea was defined as being one that participants believed would be advisable and worthwhile pursuing. A *feasible* idea was defined as being one that participants believed would receive governmental, political, and socioeconomic consideration and support in a revised Agreement or other policy venue. And an idea was defined as *likely to succeed* where participants believed that there would be positive governance and environmental performance outcomes if the idea were implemented. Participants were also asked to provide contextual commentary for their rankings.

Results

Our three-round Policy Delphi study invited 69 individual RAP stakeholders or representatives of RAP stakeholder groups from across the Great Lakes basin to contribute expert knowledge they gained from their direct and substantive experience in RAP development and/or implementation (Group A). The study achieved participation rates of 41% in Round 1, 21% in Round 2, and 47% in Round 3. This is within what Needham and de Loë (1990) suggest is the Policy Delphi's critical participation threshold of a maximum of 50 participants in an expert sample and a minimum size of 10. The volume of textual data produced by larger numbers of participants result in cost-inefficiencies related to time, product, and iteration process, and smaller numbers produce an insufficient level of idea-generation (Needham and de Loë, 1990). We invited participation in Round 3 from an additional 38 people with similar expertise simply to increase the number of rankings of governance options (Group B), although the low participation rate (13%) of Group B brought the overall rate of Round 3 participation down to 36%. Levels of participation across all rounds are provided in Table 3. Participation among Canadians and Americans was relatively even across rounds. Similarly, no single sector dominated the responses, particularly in Round 3 where quantitative data were collected (Figure 7). The results of our analysis of factors that helped or hindered the development and implementation of RAPs from the substantial contributions of dozens of experts, and the distillation of that collective knowledge into a set of lessons learned in the form of forward-looking governance options are reported in Table 4 and illustrated by Figure 8. The data are represented by the arithmetic means and mean deviations of the combined ranks for each option separately and of all rankings combined on a 7-point Likert scale of desirability, feasibility, and likelihood for success. The principal results of our study are:

1. that each of the seven governance options for reforming the governance of place-based restoration efforts in the Great Lakes is considered "highly" desirable (i.e., advisable and worthwhile pursuing) by the broad cross section of participants in our study with relatively little variation, and

TABLE 3. Levels of Participation by Sector and Citizenship in the Three-Round Policy Delphi Study. Group A was comprised of individual stakeholders or representatives of stakeholder organizations known to have direct and substantive experience in the development and/or implementation of one or more RAPs and were invited to participate in all three rounds. Group B was comprised of individual stakeholders or representatives of stakeholder organizations known to have substantive knowledge of the development and/or implementation of RAPs sufficient to allow them to provide informed opinions on the governance options ranked in final round. Numbers in parentheses represent the percentage of invitees in each round that contributed data to the survey. Provision of the categorical information below was voluntary, and information that could identify an individual was not requested or collected in order to maintain anonymity. Participants were asked to indicate the appropriate sector(s) as of the period during which they participated in RAP development and/or implementation. Because multiple sectors could be selected by a single participant, the number of sectors in a given Round therefore add to more than the total number of participants in that Round.

Category	Invitees	Round 1 Strengths & Limitations	Round 2 Affective Factors	Round 3 Ranking Remedies
Group A	69	28 (41%)	14 (21%)	33 (47%)
Group B	38			5 (13%)
Totals	107			38 (36%)
American		13	7	18
Canadian		14	7	20
Unidentified		1	0	0
Government, federal		7	5	8
Government, provincial or state		10	2	9
Government, municipal		3	1	1
Individual Citizen		2	1	2
Non-profit organization		6	5	10
Private sector, consultant		1	0	4
Private sector, industry		0	1	4
Public/citizen advisory committee		3	2	4
RAP team		8	5	9
Tribe or First Nation		0	0	1
University, academic		7	5	6
Unidentified		1	0	0

FIGURE 7. Participation in Policy Delphi Round 3 Ranking of Governance Options. There were a combined 38 participants from 107 invitees in Round 3 (or a combined 36%), with 33 (or 47%) of 69 Group A invitees and 5 (or 13%) of 38 Group B invitees contributing to these rankings. These numbers are shown as the percentage of rankings that were contributed by participants that self-identified as having RAP experience in one or more sectors. Actual counts are provided in Table 3.
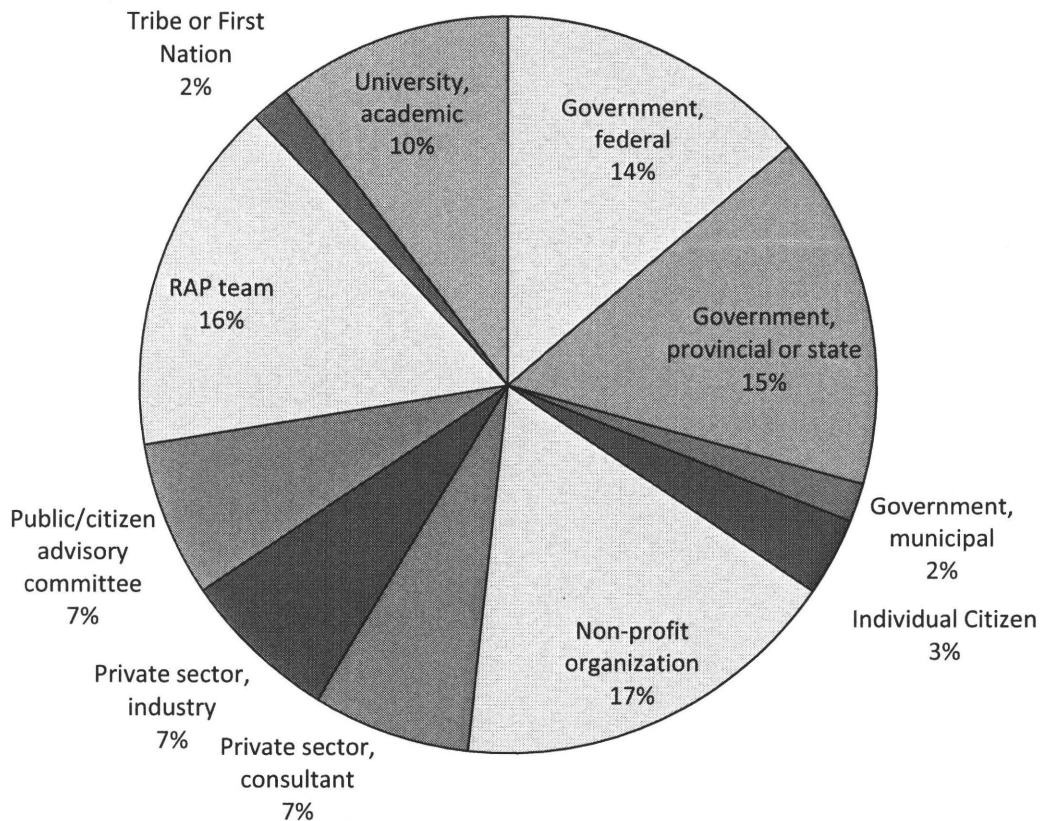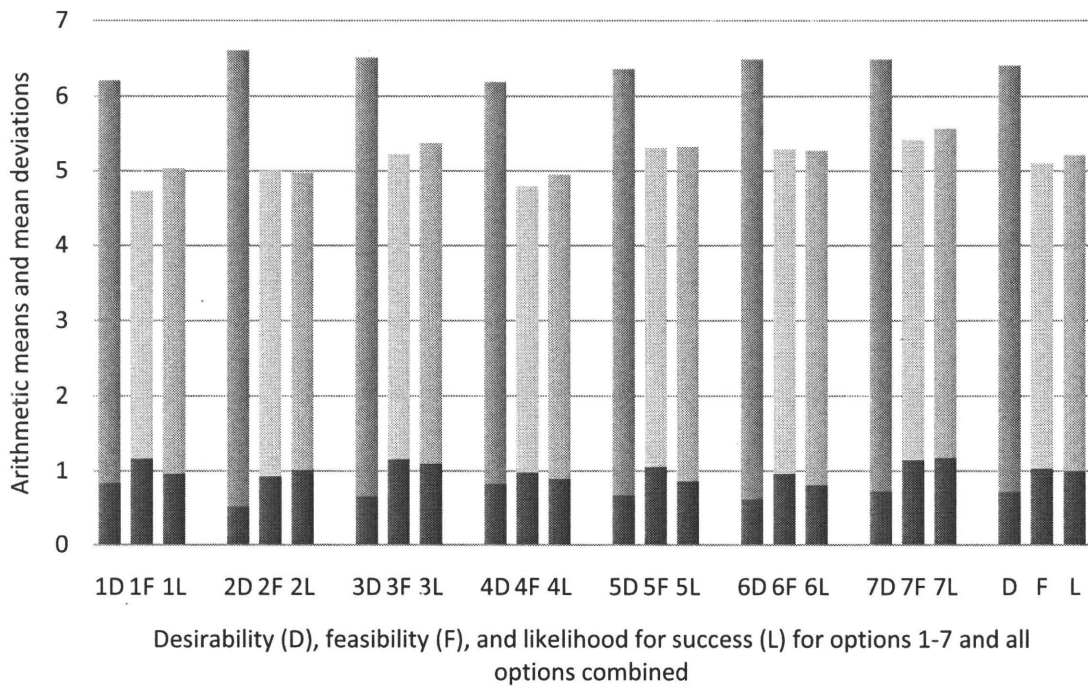
TABLE 4. Delphi Ranking Data. Absolute ranked values for desirability (D), feasibility (F), and likelihood for success (L) of each policy option. Definitions are described in the text; data are illustrated in Figure 7.

Policy Option	Ranking Type	Arithmetic Mean	Mean Deviation	No. of Rankings
1. Ensure government coordination involves senior personnel trained and experienced in the mediation of group processes and able to navigate political arenas.	1D	6.21	0.83	37
	1F	4.73	1.17	37
	1L	5.03	0.95	38
2. Ensure continuity of government coordination (meaning that coordination roles do not go unfilled for long periods of time, and that those roles are assigned adequate and dedicated time).	2D	6.61	0.52	38
	2F	5.00	0.92	37
	2L	4.97	1.01	37
3. Create stakeholder agreements and implementation workplans with assigned responsibilities, timetables, deliverables, and explicit criteria for engaging new stakeholders, ideas, and issues.	3D	6.51	0.66	36
	3F	5.22	1.15	36
	3L	5.37	1.10	37
4. More closely link institutional arrangements and workplans to legislative and regulatory instruments.	4D	6.18	0.82	37
	4F	4.78	0.98	38
	4L	4.95	0.89	37
5. Require delisting endpoints that reflect environmental quality to ensure that the scope of RAPs remain focused on required interventions.	5D	6.36	0.67	37
	5F	5.31	1.05	36
	5L	5.32	0.85	37
6. Directly link science and monitoring to policy needs regarding restoration of beneficial uses.	6D	6.49	0.61	37
	6F	5.29	0.95	38
	6L	5.27	0.81	37
7. Provide an overarching strategic RAP development and implementation framework that enables local flexibility.	7D	6.49	0.72	37
	7F	5.42	1.14	36
	7L	5.57	1.17	37
All rankings combined across all governance options.	D	6.41	0.71	261
	F	5.10	1.03	258
	L	5.21	0.99	260

FIGURE 8. Delphi Rankings of Governance Options. This figure charts the data presented in Table 4, specifically the arithmetic mean and mean deviations of the combined rankings for each of the seven governance options listed below, and for all options combined (the eighth set of bars on the chart). The seven options are listed in full in Table 4. Participants were asked to rank the desirability, feasibility, and likelihood for success of each option using a 7-point Likert scale that rated individual belief "highly", "very", and "somewhat" positive (7, 6, or 5 respectively) or "highly", "very", and "somewhat" negative (1, 2, or 3 respectively), with 4 being neutral (i.e., the participant thought the idea had merit but declined to suggest the direction of their belief). A *desirable* idea was defined as being one that participants believed would be advisable and worthwhile pursuing. A *feasible* idea was defined as being one that participants believed would receive governmental, political, and socioeconomic consideration and support in a revised GLWQA or other policy venue. And an idea was defined as *likely to succeed* where participants believed that there would be positive governance and environmental performance outcomes if the idea were implemented.

Desirability (D), feasibility (F), and likelihood for success (L) for options 1-7 and all options combined

arithmetic mean D   F   L   mean deviation (all) ■

2. that there is a general consensus that all of the options generally are both "somewhat" feasible (i.e., there would be governmental, political, and/or socioeconomic receptivity to their consideration and support) and "somewhat" likely to succeed, meaning that participants believed that there would be positive governance and environmental performance outcomes if the idea were implemented.

It bears repeating that the seven governance options were based on the collected opinions of our expert participants as to improvements on what worked with respect to RAP development and implementation, and on what could be done to remedy what did not work. Therefore, these highly desired options that are deemed to be both somewhat workable if attempted and somewhat effective if implemented, are to be considered enhancements to what is in current practice. Put another way, the participants deemed these options as exceptionally worthwhile pursuing because of the potential for them to appeal to policy and decision makers, and the potential for them to enhance procedural and attitudinal characteristics of existing RAP governance models.

Discussion

It was recognized from the outset of the RAP program that the diverse objectives and stakeholder inclusion of RAPs represented a challenging departure from the traditions of Great Lakes management that had narrowly defined problems and internalized information and decision making (e.g., Hartig and Thomas, 1988; Hartig et al., 1991). Moreover, it was recognized as equally significant that an ecosystem approach to the RAP program would also require talents and processes dramatically more diverse than the norms of traditional management if RAPs were to achieve those shared and interdependent goals (e.g., Hartig and Zarull, 1992a). We sought to characterize those talents and processes from the direct experience and collective knowledge of our study participants, and assess the degree to which RAPs have embodied some of the properties (listed in Section 2.2) thought to be central to further successful participatory restoration of local social-ecological systems in the Great Lakes.

Debates about policy reform can be preoccupied with changes to the *structure* of governance in trying to devise rules and procedures to expand participation and increase legitimacy in decision making (Hooghe and Marks, 2003). Many of the strengths and limitations of RAPs described in Round 1 reflected this debate. However, much of the response of study participants also focused on *attributes* of governance such as capacity, trust, partnerships, and social learning, emphasizing qualities and characteristics that can accompany rules and procedures. The responses of study participants reflected as much concern for *how* RAP processes have been administered and perceived as they did for *what* mechanisms were used to facilitate those processes. In our discussion of the context and implications for the results of our study, we have

selected many direct quotations from the data that are representative of various classes of opinion in the data and therefore provide a sense of those common concerns regarding the various ways that RAPs have been structured and administered. In telling the story of the research in this way we hope to illustrate how the Policy Delphi process facilitated a collective consideration of the structures and attributes of RAP governance, and how the process of analysis arrived at these particular options for improving RAP processes in future. We also emphasize that our results are the outcomes of a systematic methodology to extract the essence of collective knowledge in a set of tangible proposals, and they therefore cannot be directly ascertained from any single opinion. In that context, the selection of quotations from the data is intended to give a sense of the range of belief, perception, and consideration that produced the outcomes.

Expert participants underscored that the choice of policy tools and decision procedures are consequential.

> *We have found that a well defined workplan, a full time secretariat and a formal meeting three times a year keeps our implementation team on track and responsible to get on with implementation.* [R1C34Q10][10]

> *Lack of decision rules other than consensus [has been a limitation of our RAP].* [R1C9Q3]

However, ecosystemic and adaptive problem solving cannot be accomplished by the adoption of a clever new method alone (Miller, 1999)—restructuring the model of governance to be more 'flexible' (for example) is itself not necessarily sufficient to realize a change in our fundamental collective problem solving mentality. Rather, more ecosystemic solutions to the problems identified to exist in local RAP governance models will likely come through the implementation of familiar strategies that can only be effective where there is a will to overcome the underlying sociopolitical context of the issues (Miller, 1999).

> *Overall the RAP governance approach has been a good model for developing clean-up plans in a collaborative manner and local community buy-in.* [R1C8Q3]

> *There was an effort to solicit opinions from a wide range of people and at times this effort seemed very genuine. At other times it was clearly just a sham.* [R1C3Q3]

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[10] R1C34Q10 is a reference to, in this case, the answer in Round 1 of Contributor 34 to Question 10.

We emphasize that the responses reflected subjective qualities of each participant's experience in the administration of RAPs. It should not be assumed that governmental participants, for example, routinely responded with affirmative highlights of RAP programming,

> *Too many RAP efforts were command and control undertakings directed by agencies with budgeted funds and their contractors. RAP efforts are more productive when undertaken via true partnership efforts.* [R2C1Q4]

nor that non-governmental participants reflexively responded with negative critiques.

> *Our RAP team was very open to suggestions by our PAC, and very willing to incorporate them into the RAP documents. This was a real strength in our group, as the PAC was never made to feel that the RAP initiative was a "top down" process. As a PAC, we had confidence and trusted our RAP team members.* [R1C3Q5]

We make this point to underline the significance of the results of Round 3 as illustrated in Figure 8. From a wide range of views and perspectives we distilled a series of options that were widely agreed to have the promise of improving the performance of Great Lakes governance in ongoing local nearshore restoration initiatives. Furthermore, the options themselves can be broadly characterized as institutional design principles of sustainable governance (Becker and Ostrom, 1995; Westley, 1995; Manno and Krantzberg, 2008) and reasonably defined by phrases such as *careful attention to relationships, accountability through shared and defined responsibilities, structured learning opportunities,* and *integrative perspective.* Taken together as a framework for approaching governance reform, these options form the basis for approaching both structures *and* attributes of RAPs and other evolving Great Lakes governance models. The data below have been selected to provide a sense of the breadth of considerations in reforming governance for improved social-ecological performance. Options 1 and 2, for example, are principally about roles that could provide careful attention to relationships in RAP processes. (All of the options are listed in Table 4 and in the Methods under *Round Three, Ranking Remedies*).

> *In cases with which I'm most familiar, command/leadership devolved to state agencies who in some cases regarded the process as a distraction from principal statutorily-mandated duties. This in turn undermined citizen confidence in the process. It would be helpful, therefore, to set standards and provide training for agency officials in process matters and to consider ways of securing additional 'buy-in' from the agencies.* [R2C8Q3]

> *Early facilitation by citizen participation specialists was vital. Ultimately, though, success in collaboration depends on getting*

the right people with the right personalities into the room.
[R1C5Q3]

With budgets so constrained, this kind of training is likely to be considered a low priority. [R3C35Q3]

While careful attention to the facilitation of particular events (Option 1 above) is an important consideration in maximizing the return on public engagement exercises (both for the agencies and the public), the quality and characteristics of ongoing facilitation of long-term processes (Option 2 below) is equally important to ensure program outcomes that contribute to social-ecological resilience (Miller, 1999; Westley, 2002).

Our RAP team was very open to suggestions by our PAC, and very willing to incorporate them into the RAP documents. This was a real strength in our group, as the PAC was never made to feel that the RAP initiative was a "top down" process. As a PAC, we had confidence and trusted our RAP team members. [R1C17Q4]

If we are speaking about building trust with the public, I would say there is significant damage to relationships with the public regarding the RAPs. The public was involved when there was PAC, and felt shut out when the governments shut them down. It is my impression that this transition was not handled very well. [R1C14Q8]

Options 3 and 4 relate to linking shared and defined responsibilities more directly to RAP outcomes. Such issues of accountability have been perennially contentious over the life of the Agreement (e.g., NRC-RSC, 1985; Munton, 1988; IJC, 2006c), and the ongoing inability of responsible agencies to properly account for the collective effort expended on restoration is evident from our data (Option 3 below).

Need more accountability by clearly focusing on what an organization is to do and then public reporting of what has been done and not done. [R2C5Q8]

Little interest in governments to be so openly held accountable. [R3C21Q5]

The IJC has played a catalytic role historically. Now they play a very limited role. The IJC could do much to point out what needs to be done, by whom, etc. We need continuous and vigorous oversight of implementation. [R2C5Q9]

> *... the RAP process relies on formal and informal networks of national stakeholders working within legislatively authorized programs. ...recent experiences in similar decentralized decision-making contexts [show] that strategic uncertainty emerges within which stakeholders must work cooperatively to learn what goals they must set to address their problem(s) while also determining how to accomplish these goals [and while distributing] power among stakeholders so that diverse positions are taken into account and no individual stakeholder's position can be imposed on others. These conditions are missing with the RAP development and implementation process because state and provincial agencies rely on traditional regulatory programs that are accountable based on the principal-agent model of governance. Under this model elected representatives legislate policy goals and provide authority for carrying them out in the administrative branch. Accountability typically occurs through legislative oversight and peer review by policy elites. But this traditional hierarchical approach does not allow for participation in peer review at the local or watershed level. Such a transparent and participatory governance framework might appear to be destabilizing in relation to the traditional principal-agent approach. However, it may be argued that this approach is consistent with the apparent intent of the GLWQA to devolve decision-making to lower level government and impacted stakeholders. While there have been several RAP successes, the existing institutional context for the RAP process mitigates against accountability and deliberative problem solving that is recursive, inclusive and collaborative. Accountability is considered dynamic in such a deliberative context because decision making rules are adapted in response to what stakeholders learn through information shared among them. Thus, the focus shifts from regulatory rule-making to developing rules within a shared learning environment and framework.* [R1C28Q6]

Option 4 (below) originated from a variety of U.S. experiences with the court system being a positive, desirable catalytic element in RAP processes,

> *The court had periodic hearings on the progress in plan development and implementation. The role of the court served as a strength for the development of this plan.* [R1C26Q3]

> *In particular instances this is the best way to ensure that the remediation is completed and that it results in a positive environmental outcome.* [R3C8Q6]

> *This is where the effort on workplans should be focused.*
> *[R3C40Q6]*

but closer links between workplans and legal tools in the end was considered to be among the least feasible.

> *This is an important issue – the main failure in RAPs in Ontario has been that the RAPs have not become legislatively mandated – if nothing happens on the RAP as RAP, no laws are being broken. In the U.S., the legislative/budget process works differently.*
> *[R3C22Q6]*

> *Jurisdictional confusion could complicate this, however.*
> *[R3C7Q6]*

> *In my opinion, you will get management pushback because of staffing issues and programmatic priorities.* *[R3C1Q6]*

> *Cleaning up legacy issues doesn't mesh well with the short-term horizons of legislative processes. Durable regulatory programs and core statutes may provide stronger links.* *[R3C35Q6]*

> *For some aspects of AOC remediation and recovery there is no applicable instrument to be applied.* *[R3C8Q6]*

Options 5 and 6 could provide learning opportunities for policy with more closely linked information feedbacks between specific RAP activities and delisting objectives (Option 5) and more generally between science and management (Option 6). A principal criticism of RAPs has been a tendency for the scope of issues and related activities to extend well beyond what was originated. Not surprisingly, our data showed a desire to restrict the administrative or geographic boundaries of RAPs (Option 5 below).

> *Many of the AOCs have experienced some scope creep that has increased either the aerial extent or issues to be addressed. Governments need to take a stronger stance [against] allowing the scope to expand beyond the initial design of the program.*
> *[R1C8Q3]*

Of course, this desire was not shared by those who argue that RAPs should explicitly include the broader watershed context for the receiving waters in which the BUIs occur.

> *Scope needs to be open and inclusive, important to reach out to all direct stakeholders to address specific BUIs, but also a mission of community engagement and public awareness of the is-*

*sues that underlie BUIs and the importance of addressing water
quality issues in the community.* [R2C4Q10]

The two previous views represent distinct scopes for nearshore restoration and watershed management: one based on narrowly delineated local problems with well-defined endpoints representing a measurable AOC delisting goal, a second with explicit connection to the ways in which AOC receiving waters are impacted by social and ecological factors that extend upstream through related watersheds in various and complicated ways. The directions in which RAPs and other nearshore programs evolve in this regard need not be necessarily opposed or mutually exclusive—in fact, they could be nested one within the other in ways that are complementary. Our point is that choices going forward must make maximum use of available lessons from experience in the nearshore to date and used to determine the scope and features of those choices.

> *RAPs were initially permitted to prescribe very wide scopes,
> which allowed ... very ambitious targets for the future. In some
> cases, very impractical scopes. These wide scopes have left peo-
> ple feeling that the RAP program has failed.* [R2C29Q6]

> *If the scope is broad and general, there has been limited pro-
> gress. If focussed, specific, and quantitative, it has shown more
> progress. Quantitative use restoration targets are still missing
> 25 years into the process.* [R2C5Q6]

> *Perhaps the scope should have been better designed up front.
> Unfortunately to this day the scope still tends to be in flux.*
> [R2C21Q6]

> *Define and establish a scope of work and finish it then revaluate.*
> [R2C21Q10]

The social aspects of RAPs share a complexity with the ecological relationships involved, and both types of complexity contain a high degree of connectivity and interdependence. An ecosystem approach to such a program is taken explicitly to contend with those connections and dependencies, but it can invite a localized project to "morph" because, in a sense, everything can appear connected to everything else. Perhaps "scope creep" is indicative of the broader and persistent problem of defining what is meant by ecosystem approach (Lee et al., 1982). Despite the initial enthusiasm for the inclusive decision making of the RAP model—an innovative aspect of their early development—the history of RAPs appears to indicate that the question of which ecosystem approach is an appropriate model for RAPs has not been answered. That lack of definition for RAPs has also introduced uncertainties that have compro-

mised success. One source of uncertainty is caused by the difficulty in determining cause and effect (e.g., what can and do we know about what is going on in the ecosystem, or how much habitat is enough?). How much of that uncertainty is not just an inevitable characteristic of multiple and overlapping environmental problems, however, but is also a result of the inevitable numerous and overlapping human perspectives present in a participatory decision forum? Do scientists and lay stakeholders share the same understanding on issues such as sediment remediation, for example? Other uncertainties involved in RAP participation have included cost uncertainty (e.g., who is going to pay for this, and will it be more than projected?), uncertainty that trust and other elements of social cohesion (such as shared responsibilities and accountability) will last throughout the process, and the uncertainty of trying to reconcile the many different ways to arrive at valuations of nature (e.g., how to agree on prioritizing one beneficial use over another, and how to determine when an endpoint indicates that restoration is sufficient). And, of course, the uncertainty that all the effort for any given person or group will be worth it in the end.

Learning to better cope with ecological and sociological uncertainties through RAP processes will demand greater integration of science and policy in future RAP governance models and resolution of the issue of endpoints (i.e., static measures) and the somewhat unpredictable nature of the systems that they represent (Option 6 below).

> *I think each RAP is quite different, and while there is a need for consistency in the process, each RAP will need to be taken care of slightly differently.* [R1C14Q5]

> *There needs to be a way to incorporate new information, without losing the understanding of the how's and why's the RAP/AOC came to be in the first place.* [R1C14Q6]

> *RAPs require a open and inclusive process committed to cooperative learning.* [R1C16Q5]

Finally, Option 7 represents a reaction to the inability of the federal governments, as described earlier, to adequately coordinate and assess AOC-related activities and outcomes. The 1987 Protocol introduced RAPs with a minimum of imposed structure in order that they could adjust to local conditions, but a broader vision with a rigorous programmatic foundation has been absent. One of us was a senior Great Lakes policy analyst for the Province of Ontario in 1987 when asked to take on the role of RAP coordinator when the answer to "What is the role of a RAP coordinator?" was "We don't know" (Krantzberg, pers. obs.). According to Botts and Muldoon (2005), the Great Lakes regime generally lacked a plan for institutional development

following adoption of the Protocol; perhaps this is reflected in part in the absence of an overarching RAP strategy.

> *Since the RAP type of process had never occurred before, the agencies did not spend enough time thinking through the design of how, when, why, where, etc. This meant that many parts of the process occurred as they were thought up.*[R2C7Q5]

> *Governments did not set implementation priorities based on the status or strength of the cleanup recommendation; rather, each RAP Team lobbied for funding support. There was no collaboration on the direction to implement all the RAPs; instead, it was dog-eat-dog and the best RAP won.* [R1C24Q7]

> *Silo effect of government agency programs tends to restrict efficient use of resources or creative new approaches to problem solving.* [R3C5Q6]

> *RAPs have lost their momentum in many AOCs due to endless planning and insufficient attention to and implementing cleanup actions. IJC no longer performing evaluation/assessment/communication function, so many RAPs are unaware of how they are progressing relative to others. Sharing of success stories is not being conducted and each RAP struggling to develop their own quantitative listing/delisting criteria is a waste of time and contributes to loss of momentum and increase in public disengagement.* [R1C29Q6]

> *Need a clear and understandable general framework outlining the coordination processes so that the many players have a common understanding of roles and expectations.* [R2C17Q8]

Conclusions

The purpose of policy-directed research is not to decide or to advocate, but to provide decision makers with options through an analysis and rationale of alternative choices and additional information upon which they can base their judgments (Burton et al., 2002). Our study was premised on the need for an introspective investigation of the strengths and limitations of the RAP program. Many people have deeply held opinions on what has ailed RAPs based on their direct experience with the program, of course, but little formal empirical data on what has worked (and not worked) with respect to RAPs has been generated in recent years. Moreover, the program has never, to the best of our knowledge, received a comprehensive appraisal of the program's performance over a quarter-century. Our goal was to provide a framework upon which

to base future judgments about RAPs and other forms of governance for nearshore social-ecological restoration.

The potential for significant changes in binational Great Lakes programming following the 2006-2007 review of the Agreement and the 2010-2011 renegotiation of the Agreement means that it is imperative that potential lessons for informing those changes be gathered and presented in a way that is accessible to a wide range of policy makers and other stakeholders throughout the Great Lakes community. To do this, we used the Policy Delphi research methodology to systematically access the substantial knowledge base of a broad range of RAP participants with direct experience and influence in the program's evolution. We translated that knowledge into potential remedies of RAP governance through an iterative structured process of refining the responses of participants in our study. From that inquiry we conclude that there is a diversity of opinion on several properties or characteristics of RAPs that would be expected from a such pluralistic group. But we also found an unanticipated level of consensual enthusiasm for all of the options for future reform of RAPs and other forms of Great Lakes governance that emerged from our analysis. We believe that this consensus stems from those same early sources of enthusiasm mentioned in our introduction and that we restate now to better reflect our body of evidence and our characterization of the governance options:

1. the prospect for more effective inclusion of stakeholders in decision making,

2. the prospect for greater accountability through shared responsibilities, and

3. the prospect that actions taken and their consequences could be more carefully evaluated for their impact and learning potential with respect to both ecological *and* social processes.

It was also recognized from the outset of the RAP program that "there are limits to what technical and scientific programs can accomplish when *fundamental elements are not only technological but also societal and attitudinal*. As technological and scientific limitations on progress become more apparent, the challenge becomes increasingly one of engaging public support for the new approaches and programs that are needed" (IJC, 1984; emphasis added). Our results characterize the duality of that challenge as comprising four general elements that we have termed *careful attention to relationships, accountability through shared and defined responsibilities, structured learning opportunities*, and *integrative perspective*.

> *Structured involvement. "Structured" doesn't mean "controlled."*
> *It means an approach to the implementation processes that is thoughtfully structured to elicit meaningful involvement.*
> [R2C7Q5]

> *It is all about relationships.* [R1C16Q4]

But most importantly, our results also underscore this use of "thoughtfully" and "meaningful" as attributes of governance. Such qualities require a demanding and comprehensive problem definition that embraces the breadth of human context in which the problems underlying BUIs, for example, are embedded (Miller, 1999).

> As long as action remains voluntary and unfunded, we will inch along and only make sporadic progress. The "delisting" strategy is not a "healthy ecosystem" strategy. A shift to a healthy watershed framework could re-align strategies around a vision-based approach for restoring whole watersheds within the Great Lakes tributaries, of which addressing contaminated sites and degraded waters would be a goal. New metrics such as climate resilience, biodiversity, ecosystem services could bring Great Lakes restoration into the 21st Century. By and large, the RAP approach has failed (utterly) to achieve what we hoped for in 1987, and we need a fresh approach that builds on today's scientific knowledge, ecological trends, and how governments work (or don't) to address long-term ecological problems.
> [R3C35Q10]

One possible approach to effectively incorporate needed changes in both the structure and attributes of place-based management for Great Lakes restoration through RAPs (and other mechanisms) is a process of utilization-focused, developmental evaluation. Utilization-focused evaluation is a process of situational responsiveness guided by the intended uses of that evaluation (Patton, 2008). Intended uses could be to strengthen the linkages between science and policy, for example, and retain the focus of the RAP delisting strategy by using those linkages to carefully embed place-based initiatives in a more comprehensive 'healthy ecosystem' framework. Developmental evaluation is a system of monitoring that guides program decisions makers through processes of social innovation development, helping them to create adaptive responses to complex dynamics (Patton, 2010). More thoughtful accountability and more meaningful participation is the goal, and perhaps an aspect of that "fresh approach" involves new forms of evaluation that provide ongoing feedback to program development and the more rigorous adaptation of principles to practice in local contexts. How forms of participatory decision making and evaluation more carefully tailored to the complexities of social-ecological systems might be encouraged within a technocorporate state, however, remains unresolved (Miller, 1999). Our data demonstrate a widespread enthusiasm, however, for such 'fresh' approaches.

> The design of RAPs is always going to be a challenge. [R2C29Q5]

> I am an optimist. [R3C41Q4]

Acknowledgements

Many thanks to Karen Szala-Meneok and Johnny Saldaña for improving the study design. Deep appreciation goes to the dozens of particpants across the Great Lakes basin who shared their invaluable knowledge and experience.

Literature Cited

Adams WM, Brockinton D, Dyson J, Vira B, 2003. Managing tragedies: understanding conflict over common pool resources. Science, 302: 1915-1916.

ARC [Agreement Review Committee]. 2007. Report to the Great Lakes Binational Executive Committee: Volumes 1, 2, and 3. Accessed 30 Oct 2010 at http://binational.net/glwqa_2007_e.html.

Becker CD, Ostrom E. 1995. Human ecology and resource sustainability: the importance of institutional diversity. Annual Review of Ecology and Systematics, 26: 113-33.

Botts L, Muldoon P. 2005.Evolution of the Great Lakes Water Quality Agreement. Michigan State University Press.

Briggs S. 2003. Command and control in natural resource management: revisiting Holling and Meffe. Ecological Management and Restoration, 4: 161-162.

Buck AJ, Gross M, Hakim S, Weinblatt J. 1993. Using the Delphi process to analyze social policy implementation: A post hoc case from vocational rehabilitation. Policy Sciences, 26: 271-288.

Bulkley JW, Donahue MJ, Regier HA. 1989. The Great Lakes Water Quality Agreements: how to assess progress toward a goal of ecosystem integrity. In: Post Audits of Environmental Programs and Projects. Gunnerson CG, editor. pp. 27-42. Proceedings of a session sponsored by the Environmental Impact Analysis Research Council of the American Society of Civil Engineers in conjunction with the ASCE Convention in New Orleans, Louisiana, 11 Oct 1989.

Burton I, Huq S, Lim B, Pilifosova O, Schipper EL. 2002. From impacts assessment to adaptation priorities: the shaping of adaptation policies. Climate Policy, 2: 145-159.

Caldwell LK. 1988. Implementing an ecological systems approach to basin-wide management. In: Perspectives on Ecosystem Management for the Great Lakes: A Reader. Caldwell LK, editor. pp. 1-29. State University of New York Press.

Colborn TE, Davidson A, Green SN, Hodge RA, Jackson CI, Liroff RA. 1990. Great Lakes, Great Legacy? The Conservation Foundation and the Institute for Research on Public Policy.

Collins J, Hanlon A, More SJ, Wall PG, Duggan V. 2009. Policy Delphi with vignette methodology as a tool to evaluate the perception of equine welfare. The Veterinary Journal, 181: 63-69.

Dalkey N, Helmer O. 1963. An experimental application of the Delphi method to the use of experts. Management Science, 9: 458-467.

de Loë R. 1995. Exploring complex policy questions using the policy Delphi. Applied Geography, 15: 53-68.

Dewey J. 1938. Experience and Education. Macmillan.

Franklin KK, Hart JK. 2007. Idea generation and exploration: benefits and limitations of the policy Delphi method. Innovation in Higher Education, 31: 237-246.

Gabb J, Balen R, Gibbs G, Hall C, Teal A. 2006. Victoria Climbié inquiry data corpus project: using the Delphi method in multidisciplinary child protection research. British Journal of Social Work, 36: 577-596.

GAO [United States General Accounting Office]. 2003. Great Lakes: an overall strategy and indicators for measuring progress are needed to better achieve restoration goals. Report GAO-03-515.

GAO [United States General Accounting Office]. 2009. EPA needs a cohesive Plan to clean up the Great Lakes Areas of Concern. Report 09-P-0231.

Gurtner-Zimmerman A. 1995. A mid-term review of Remedial Action Plans: difficulties with translating comprehensive planning into comprehensive action. Journal of Great Lakes Research, 21: 234-247.

Hartig JH, Lovett-Doust L, Zarull MA, Leppard S, New LA, Skavroneck S, Eder T, Coape-Arnold T, Daniel G. 1991. Overcoming obstacles in Great Lakes remedial actions plans. International Environmental Affairs, 3: 91-107.

Hartig JH, Law N. 1994. Institutional frameworks to direct development and implementation of Great Lakes Remedial Action Plans. Environmental Management, 18: 855-864.

Hartig JH, Law NL, Epstein D, Fuller K, Letterhos J, Krantzberg G. 1995. Capacity-building for restoring degraded areas in the Great Lakes. International Journal of Sustainable Development and World Ecology, 2: 1-10.

Hartig JH, Thomas RL. 1988. Development of plans to restore degraded areas in the Great Lakes. Environmental Management, 12: 327-47.

Hartig JH, Vallentyne JR. 1989. Use of an ecosystem approach to restore degraded areas of the Great Lakes. Ambio, 18: 423-428.

Hartig JH, Zarull MA. 1992a. A Great Lakes mission. In: Under RAPs: Toward Grassroots Ecological Democracy in the Great Lakes Basin. Hartig JH, Zarull MA, editors. pp. 5-35. University of Michigan Press.

Hartig JH, Zarull MA. 1992b. Keystones for success. In: Under RAPs: Toward Grassroots Ecological Democracy in the Great Lakes Basin. Hartig JH, Zarull MA, editors. pp. 263-279. University of Michigan Press.

Hartig JH, Zarull MA, Law NL. 1998. An ecosystem approach to Great Lakes management: practical steps. Journal of Great Lakes Research, 24: 739-750.

Hartig JH, Zarull MA, Reynoldson TB, Mikol G, Harris VA, Randall RG, Cairns VW. 1997. Quantifying targets for rehabilitating degraded areas of the Great Lakes. Environmental Management, 21: 713-723.

Hartig JH, Wever GH, Law NL. 1994. Applying total quality management to Remedial Action Planning in the Great Lakes. Journal of Environmental Engineering and Management 4:23-27.

Holling CS. 1995. What barriers? What bridges? In: Barriers and Bridges to the Renewal of Ecosystems and Institutions. Gunderson LH, Holling CS, Light SS, editors. pp. 3-34. Columbia University Press.

Holling CS, Meffe G. 1996. Command and control and the pathology of natural resource management. Conservation Biology, 10: 328-337.

Hooghe L, Marks G. 2003. Unraveling the central state, but how? Types of multi-level governance. American Political Science Review, 97: 233-243.

IJC [International Joint Commission]. 1976. Fifth Annual Report.

IJC [International Joint Commission]. 1984. Second Biennial Report.

IJC [International Joint Commission]. 2003. Status of Restoration Activities in Great Lakes Areas of Concern: A Special Report.

IJC [International Joint Commission]. 2006a. Advice to Governments on their Review of the Great Lakes Water Quality Agreement: A Special Report to the Governments of Canada and the United States.

IJC [International Joint Commission]. 2006b. Priorities 2003-2005: Priorities and Progress under the Great Lakes Water Quality Agreement.

IJC [International Joint Commission]. 2006c. Thirteenth Biennial Report.

IJC [International Joint Commission]. 2009. Work Group Report on Nearshore Framework.

Jackson J. 2010. Whither Remedial Action Plans (RAPs)? Great Lakes United. Accessed 12 Dec 2010 at http://www.glu.org/news/2010/03/whither-remedial-action-plans-raps.

Kellogg WA. 1998. Adopting an ecosystem approach: local variability in Remedial Action Planning. Society & Natural Resources, 11: 465-483.

Krantzberg G. 1998. After more than ten years of effort, are Remedial Action Plans making a difference? Journal of Great Lakes Research, 24: 485-486.

Krantzberg G. 2002. Restoring active participation. Journal of Great Lakes Research, 28: 491-492.

Krantzberg G. 2003. Keeping remedial action plans on target: lessons learned from Collingwood Harbour. Journal of Great Lakes Research, 29: 641-651.

Krantzberg G, Houghton E. 1996. The Remedial Action Plan that led to the cleanup and delisting of Collingwood Harbour as an Area of Concern. Journal of Great Lakes Research, 22: 469-483.

Landeta J. 2006. Current validity of the Delphi method in social sciences. Technological Forecasting & Social Change, 73: 467-482.

Landre BK, Knuth BA. 1993. The role of agency goals and local context in Great Lakes water resources public involvement programs. Environmental Management, 17: 153-165.

Lee BJ, Regier HA, Rapport DJ. 1982. Ten ecosystem approaches to the planning and management of the Great Lakes. Journal of Great Lakes Research, 8: 505-519.

Linstone HA, Turoff M, editors. 1975. The Delphi Method: Techniques and Applications. Addison-Wesley Publishing.

Lubell M, Sabatier PA, Vedlitz A, Focht W, Trachtenberg Z, Matlock M. 2005. Conclusions and recommendations. In: Swimming Upstream: Collaborative Approaches to Watershed Management. Sabatier PA, Focht W, Lubell M, Trachtenberg Z, Vedlitz A, Matlock M, editors. pp. 261-296. MIT Press.

MacKenzie, SH. 1993. Ecosystem management in the Great Lakes: some observations from three RAP sites. Journal of Great Lakes Research, 19: 136-144.

MacKenzie, SH. 1997. Toward integrated resource management: lessons about the ecosystem approach from the Laurentian Great Lakes. Environmental Management, 21: 173-183.

Manno J, Krantzberg G. 2008. Rediscovering and revitalizing the Great Lakes governance. In: Governance for Sustainability Issues, Challenges, Successes. Bosselmann K, Engel R, Taylor P, editors. pp. 159-170. IUCN Environmental Policy and Law Paper No. 70.

Miller A. 1985. Ideology and environmental risk management. The Environmentalist, 5: 21-30.

Miller A. 1999. Environmental Problem Solving: Psychosocial Barriers to Adaptive Change. Springer.

Munton D. 1988. Toward a more accountable process: the Royal Society-National Research Council Report. In: Perspectives on Ecosystem Management for the Great Lakes: A Reader. Caldwell LK, editor. pp. 299-317. State University of New York Press.

Needham RD, de Loë RC. 1990. The Policy Delphi: purpose, structure, and application. The Canadian Geographer, 34: 133-142.

NRC-RSC [National Research Council of the United States and The Royal Society of Canada]. 1985. The Great Lakes Water Quality Agreement: An Evolving Instrument For Ecosystem Management. National Academies Press.

OAG [Office of the Auditor General of Canada]. 2001. A legacy worth protecting: charting a sustainable course in the Great Lakes and St. Lawrence River basin; Chapter 1 of the Report of the Commissioner of the Environment and Sustainable Development. Public Works and Government Services Canada.

OAG [Office of the Auditor General of Canada]. 2008. Areas of Concern in the Great Lakes Basin; Chapter 7 of the Status Report of the Commissioner of the Environment and Sustainable Development. Public Works and Government Services Canada.

OPAC [Ontario Public Advisory Council]. 2006. Great Lakes Hotspots: Ontario Citizens Speak Up: Highlights. Ontario Public Advisory Council.

Patton MQ. 2008. Utilization-Focused Evaluation. Fourth edition. Sage.

Patton MQ. 2010. Developmental Evaluation: Applying Complexity Concepts to Enhance Innovation and Use. Sage.

Plummer R, Armitage DR. 2007a. A resilience-based framework for evaluating adaptive co-management: linking ecology, economics and society in a complex world. Ecological Economics, 61: 62-74.

Plummer R, Armitage DR. 2007b. Charting the new territory of adaptive co-management: a Delphi study. Ecology and Society, 12.2: art10.

Regier HA, Jones ML, Addis J, Donahue M. Great Lakes–St. Lawrence River basin assessments. 1999. In: Bioregional Assessments: Science at the Crossroads of Management and Policy. Johnson KN, Swanson FJ, Herring M, Greene S, editors. pp. 133-165. Island Press.

Richards L. 2009. Handling Qualitative Data: A Practical Guide. Second edition. Sage.

Sabatier PA, Focht W, Lubell M, Trachtenberg Z, Vedlitz A, Matlock M, editors. 2005. Swimming Upstream: Collaborative Approaches to Watershed Management. MIT Press.

Saldaña J. 2009. The Coding Manual for Qualitative Researchers. Sage.

Turoff M. 1970. The design of a policy Delphi. Technological Forecasting and Social Change, 2: 149-171.

Turoff M. 1975. The policy Delphi. In: The Delphi Method: Techniques and Applications. Linstone HA, Turoff M, editors. pp. 84-100. Addison-Wesley.

Vallentyne JR, Beeton AM. 1988. The ecosystem approach to managing human uses and abuses of natural resources in the Great Lakes basin. Environmental Conservation, 15: 58-62.

Westley F. 1995. Governing design: the management of social systems and ecosystems management. In: Barriers and Bridges to the Renewal of Ecosystems and Institutions. Gunderson LH, Holling CS, Light SS, editors. pp. 391-427. Columbia University Press.

Westley F. 2002. The devil is in the dynamics: adaptive management on the front lines. In: Panarchy: Understanding Transformations in Human and Natural Systems. Gunderson LH, Holling CS, editors. pp. 333-360. Island Press.

DISCUSSION

> The state of water always reflects, in one way or another, the
> state of society.
>
> —Jamie Linton, 2010
> *What is Water?*

The 2009 State of the Great Lakes Conference reported the overall status of the Great Lakes ecosystem as "mixed" because conditions assessed ranged from good to poor, with some conditions improving and some deteriorating (Canada and the United States, 2009). From the evidence in the chapters of this thesis, Linton appears correct: little more could be said of the performance of Great Lakes governance (as it is presumed to reflect the state of society), other than it is, at best, 'mixed'. For every time I encountered a word such as 'successful' or 'innovative' used to describe the history and design, respectively, of the Great Lakes Water Quality Agreement and its ecosystem approach or its Remedial Action Plan program, a word such as 'failure' or 'limited' was used elsewhere in assessing the impact of these initiatives. I do not believe that to be the point exactly, however: we should expect imperfect implementation. The issue is whether we know how to learn from and improve upon 'mixed'. So while I agree with Linton, I think that improving Great Lakes governance requires that we turn his phrase around in the form of question: could the state of society learn to reflect the state of water? By that I mean, for example, could rigid management processes become more fluid, or closed organizational cultures more transparent? Could "a new role for science that probes uncertainty and facilitates social learning" (Regier et al. 1999) be created? Could an adaptive governance model evolve in the Great Lakes to significantly increase our "social responsiveness to ecosystem dynamics" (Folke et al. 2005)?

The role of policy-related research is to inform the possibilities and choices implied by these questions. My research was intended to contribute to our understanding of factors that facilitated or limited progress on restoring the Great Lakes, particularly regarding the human dimensions of place-based restoration that impel and could enhance our social responsiveness. I addressed those factors by proposing a series of remedies for evolving Great Lakes governance, particularly related to future revisions to the Agreement, decisions about future investments in RAPs and other place-based initiatives, and the development of a comprehensive nearshore restoration strategy. Ultimately, the conceptual framework coheres the findings and implications of this research as they relate to the human-environment interactions involved in develop-

ing, implementing, and evaluating regional and localized aspects of social-ecological restoration programs (Figure 9). *This framework is the culmination and principal contribution of this thesis both to scholarship and to policy renewal.*

The framework is circular (as opposed to a more linear, staged model), intended to be viewed as a holistic, ongoing, situational analysis that embodies a 'people in place' focus to linking evaluative methodologies with policy renewal processes across scales of social interaction (i.e., deliberate social learning). Adaptive governance encompasses three domains in the framework that correspond to established levels of institutional analysis (e.g., Sproule-Jones, 2002): constitutional choice (i.e., political and societal processes), collective choice (i.e., policy and decision processes), and operational choice (i.e., resource use and management processes). The dashed lines represent 'membranes' that restrict or facilitate the flow of information depending on the rules and conventions of the institutional regime being modelled. Traditional governance characteristically permits only a linear and downward flow that negates the possibility for double-loop learning. Membranes in an adaptive governance model intentionally open to encourage a return or upward (and outward) flow of information that allows for double-loop learning (and perhaps a more transformative form of triple-loop learning).

The three domains in the framework are nested to indicate that the "problem domain" is the entire social system, that problems of environmental governance cannot be restricted to subsets of issues (Westley, 1995, 2002), and that adaptive problem solving is multi-scalar (Levin, 1999). The framework advances governance because the processes *within* domains are linked explicitly *across* domains. The framework is adaptive because it bridges boundaries that traditionally separate society from policy decisions and isolate policy decisions from management activity feedbacks (i.e., restrict learning). The framework allows for incorporation of the mechanisms of new governance described earlier by Lemos and Agrawal (2006) such as the integration of multiple actors and sources of knowledge, sufficient flexibility in functional performance and programming, and explicit cross-scale interaction. The framework also directly engages the policy options [numbered in brackets; see Table 4] that emerged in Chapter Five by:

- requiring the leadership and social cohesion necessary for improved group processes (i.e., personnel trained in mediation and group facilitation [1], retaining such skilled people in key roles over time [2], and the continuity of program coordination [3]);

- incorporating those that provide improved internal structure (i.e., stakeholder agreements and implementation workplans that link stakeholders to commitments and institutional arrangements to legislative and regulatory instruments [4]);

- incorporating those that create strategic linkages between objectives and outcomes (i.e., focus of RAP scope on required interventions [5]), science and policy (i.e., science and monitoring directly linked to policy [6]), and an overarching strategic RAP development and implementation framework [7].

Figure 9. A conceptual framework for adaptive governance, problem solving, decision making, and management. Adaptive governance encompasses three domains in the framework that correspond to established levels of institutional analysis: constitutional choice (political and societal processes), collective choice (policy and decision processes), and operational choice (resource use and management processes). The dashed lines represent 'membranes' that restrict or facilitate the flow of information depending on the rules and conventions of the institutional regime being modelled. Traditional governance characteristically permits only a linear and downward flow that negates the possibility for double-loop learning. Membranes in an adaptive governance model intentionally open to encourage a return or upward (and outward) flow of information that allows for double-loop learning (and ultimately, perhaps a more transformative form of triple-loop learning). The three domains in the framework are nested to indicate that the "problem domain" is the entire social system, that problems of environmental governance cannot be restricted to subsets of issues, and that adaptive problem solving is multi-scalar. The framework advances governance beyond the 'three pillars of sustainable development' because processes within domains are linked explicitly across domains—it is adaptive because it bridges boundaries that traditionally separate society from policy decisions and isolate policy decisions from management activity feedback loops.
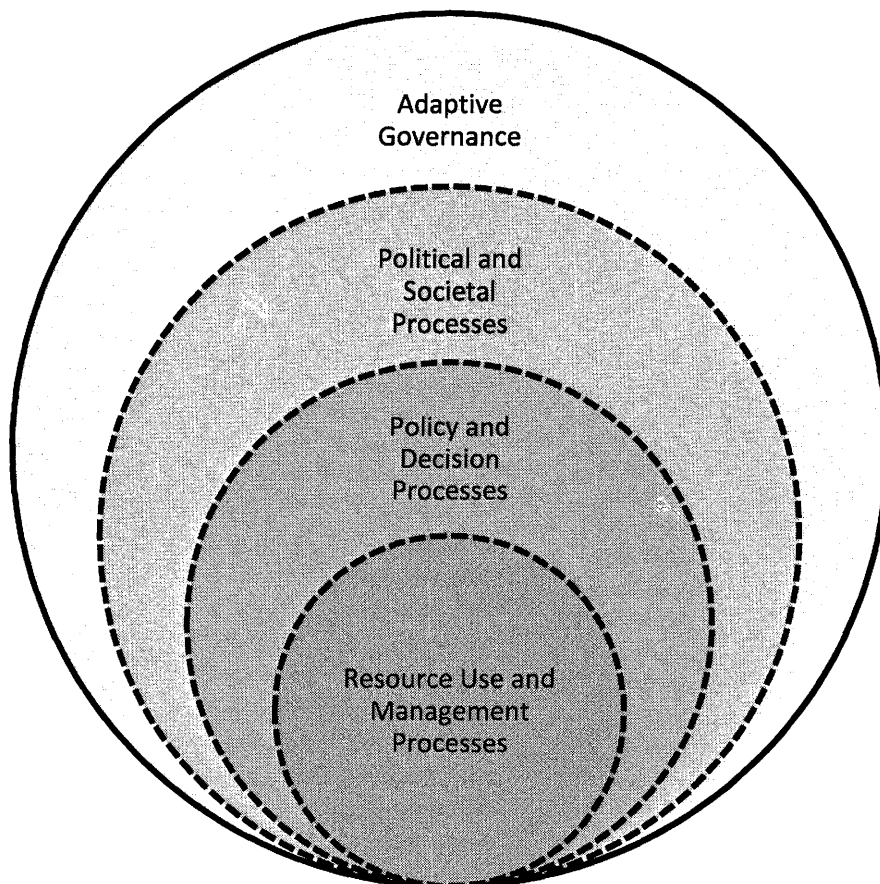
Despite advances in understanding the natural science of the Great Lakes, we have yet to effectively integrate that understanding with collective problem solving based on an equally thorough appreciation for the psychosocial and sociopolitical barriers to restoration and maintenance of the Great Lakes. Anticipating and guiding human system responses in collective problem solving requires a sophisticated understanding of how people and organizations handle incomplete and uncertain scientific information and how they incorporate, ignore, or reinterpret that information in decision making (Moran 2010). This research agenda includes both attention to individual cognition and to risk judgments and decision making in groups, organizations, and throughout institutional environmental regimes (Miller 1999; Moran, 2010). Without such integration, aspects of Great Lakes knowledge (such as natural science) could continue to accumulate, but the management system will not necessarily have developed mechanisms for responding to the uncertain state of the system due to changing (and neglected) social conditions (Hilborn, 1987). Such learning systems require that social considerations be explicitly integrated with ecological ones in a problem solving regime that combines local knowledge, formal research, and institutional support (Stafford Smith et al., 2007). Without such integration, implementation will continue to underperform and disappoint, as is illustrated by the reactions to RAP processes that embraced or ignored those social considerations to varying degrees:

> The RAP is unique in its ability to bring diverse constituencies and expertise to the table. [R1C2Q3]

> I felt privileged to be involved in the RAP process from the very beginning. [R1C3Q5]

> This eventually evaporated and the RAP/PAC was neglected and effectively disbanded. [R1C3Q4]

> Governmental agencies do what they want, in the end, leaving distrust and a sour taste behind. [R1C2Q8]

The observation that a lack of policy integration of social and ecological considerations significantly limits performance in environmental management is generally applicable (Miller, 1999; Moran, 2010), and therefore the conclusions and implications of this research and the conceptual framework in Figure 9 should have universal application. I suggest that the application of this framework could improve current Great Lakes governance, and secondarily could again position the Great Lakes regime as a source for policy innovation as it has been in previous decades (see also MacDonagh-Dumler, 2009). The framework could also assist in reviving the development and implementation of RAPs, where government agencies have been engaged in collective choice exercises "with little understanding of the wider significance of institutional designs for successful RAP performance" (Sproule-Jones, 2002). The ultimate accomplishment for

my research would be for it to play a role in institutionalizing a comprehensive social-ecological perspective and approach to policy development, evaluation, and reform as reflected in the policy options generated through the Delphi study reported in Chapter Five and the nested, open framework for information flow, analytic decisions, and social learning processes illustrated in Figure 9.

I believe that the decline in the governance of the Great Lakes, the loss of confidence in the IJC and other responsible authorities, the waning of participatory processes of RAPs (for example), and the continuing technocratic character of Great Lakes policy processes is evidence of a neglect of the critical role of the human element in contributing to or hindering success in meeting the goals of the Agreement. The appreciation for the importance of social-ecological perspectives on how to integrate those elements more effectively is too often superficial insofar as that appreciation is developed in practice. Environmental management has historically been limited essentially to ameliorating the biophysical symptoms of environmental decline while their underlying psychosocial causes have gone largely unexamined (Miller, 1999). For social-ecological decision processes to acquire this integration of knowledge, governance will need a enhanced capacity and unprecedented cooperation to manage ecological complexity and psychosocial conflict. Two themes represent the critical components needed for this integration, the *why* and *how* of any successful measure of adaptive governance: learning and leadership.

Learning

Theories of learning as a signature human trait have been a major topic of psychological inquiry (e.g., Benjamin et al., 2008) and organizational development (e.g., Argyris and Schön, 1978, 1996). Learning is a dimension of organizational performance (e.g., Holsapple and Joshi, 2000) that has received considerable attention, particularly in the business management literature (e.g., Senge 1990; Flood 1999), but also with specific regard for sustainability (Parson and Clark, 1995) and the Great Lakes (Milbrath, 1988). The study of learning within organizations has typically comprised the aggregate of learning by individuals, although this has been changing to reflect 'ecologies of learning' throughout and among organizations (Levitt and March, 1988; March, 2008). Learning has been conceptualized in numerous ways, but as I emphasized in my Introduction, two definitions relating both the procedural and cultural aspects of learning have particular relevance to reconsidering the culture and routines of Great Lakes governance.

Social learning occurs when people engage one another and share diverse perspectives and experiences to develop a common framework of understanding and a basis for joint action (Schusler et al., 2003). In the broadest sense, social learning is the acquisition of knowledge within groups, organizations, or societies (McDaniels and Gregory, 2004). This has significant implications for governance reform, in that it implies the need and potential for broad and inclu-

sive management and decision processes that incorporate diverse views and sources of knowledge. Crawford et al. (2005) have a more focused characterization of learning: the iterative use of feedback information from manipulative management interventions in the system being managed to reduce 'key uncertainties' (which they cite as gaps in knowledge that prevent the selection of an appropriate management option from among alternatives because the effect of various management actions on outcomes cannot be predicted with adequate certainty). This has broad implications for policy reform, in that it implies that management should explicitly recognize uncertainty and take deliberate steps to reduce it in the course of conducting management programs. Peterson et al. (2003) suggest that even apparently rational management approaches can trigger ecological collapse of a resource or system, and lessons from the "new ecology" (Scoones, 1999) therefore suggest that management routines must quickly evolve to accommodate unpredictable variation, complexity, uncertainty, and the acceptance of periodic 'failure' (which can possibly produce learning). In this sense, policies are posed as questions rather than answers, and management actions are treated as experimental interventions rather than the imposition of a priori solutions (e.g., Landau 1973; Lee, 1993). Learning is not the accumulation of small pieces of a single complete truth, "but rather is an unfolding and ongoing social process requiring community and communication, a process that advances by gradually correcting errors through the use of intelligence in the activity of problem-solving" (Norton, 2003).

In only a very limited sense did the RAP program unfold in ways that resemble such an ongoing social process, however, despite that RAPs were repeatedly referred to as "experiments" in large-scale environmental restoration (e.g., Hartig and Zarull, 1992; Sproule-Jones, 2002). An experiment can be described as "the action of trying anything" or a "remedy to be tried," although a more rigorous and methodical application involves a "course of... action or operation undertaken in order to discover something unknown [or] to test a hypothesis" (OED, 2010). The evidence suggests that the development and implementation of RAPs were haphazardly experimental. If the governments are serious about maintaining participatory problem solving in localized governance models, and serious about adopting rigorous regional methodologies for learning such as adaptive management, then initiatives such as RAPs and other Great Lakes programs currently being developed and promoted as adaptive must begin to examine the inherent deficiencies in management behaviour and performance outlined in Chapters Two and Three, incorporate the design principles for feedback and learning detailed in Chapter Four, and the attributes for sustained group processes explicit in policy options 1, 2, and 3 as detailed in Chapter Five.

Leadership

Learning has tremendous appeal as a reason *why* we should pursue adaptive governance. Recall, however, that the measure of adaptive governance—and not simply its appeal—is our capacity to remedy the deficiencies in how we conceptualize the dynamics of social-ecological systems and how we formulate collective action to cope effectively with those dynamics. Further, the answer to *how* we might achieve adaptive governance will be rather unappealing to a great many people because of how they will perceive the costs and benefits. Miller (1999) has captured this overwhelming challenge in stating that

> the capacity of most industrial societies to deal effectively with the environmental problems that confront us is inadequate. Not only are conventional problem solving systems based on flawed epistemological assumptions and inappropriate cognitive styles but they are driven by a materialistic ideology that has resulted in the overexploitation of natural resources. To make matters worse, the organizational structures entrusted with natural resource management appear to be more concerned with self-protection than adaptive problem solving, in a political system controlled by elites in pursuit of their own self-interest. The reforms... are fragmentary and uncoordinated, tending to address only isolated aspects of the complex psychosocial and ecological mess we have created for ourselves.

Although not encouraged that prospects for a widespread adoption of adaptive problem solving are better than "dim", Miller (1999) considers greater leadership capacity in two areas to be the best hope for adaptive change: more effective leadership from the professional bureaucratic and scientific establishment, and the intentional inclusion of 'wise integrators' or 'sages' in collaborative problem solving. A sage exhibits "wisdom, the capacity to make sensible judgments in the face of great uncertainty while being acutely aware that of their fallibility in making such decisions" (Miller, 1999). Leadership can also come from across the social spectrum—in RAPs, for example, leadership can (and did) emanate both from within and outside of governmental agencies.

Leadership as an outward extension of the authority, moral and otherwise, needed to create the capacity for stakeholders to act (Lee 1993; Stoker 1998). I believe that the degree to which both individuals and organizations take on leadership roles is a benchmark of adaptive governance and critical for the type of inspired collective problem solving we will require to appropriately address the challenge described by Miller (1999). Leadership will be needed to institute meaningful changes in governance in order that institutional processes encourage and combine different types of knowledge, create opportunities for self-organization, and nurture the development of capacity for renewal (Folke et al., 2003, 2005). Autocratic closed-mindedness is often mistaken for leadership, whereas the role of a thoughtful leader is to encourage

and enable people to take risks. Leadership should "develop and sustain an internal climate that supports an intent focus on task requirements and performance and a shared commitment to explore and learn from new ideas, dissenting views, and unanticipated problems and opportunities" (Hackman and Edmondson, 2008). Westley (1995) suggests that this is the essence of management itself, to synthesize a diversity of old knowledge and form new perspectives, and that done effectively, this is the essence of leadership. Such leadership appreciates the distinction between commanding instruction and fostering capacity. This appreciation is required to reduce policy implementation deficits related to the complexity of the regime and the uncertainty of the systems. It is also required in order to relate to the ways in which governance can enable or constrain broader social collaboration and learning that would more fully realize ecosystem-based management. In the context of that distinction, much of the evidence presented in the preceding chapters illustrates where leadership itself is in deficit, at both the individual and the institutional scale.

It must be recognized that relationships are therefore key to understanding and engaging with complex dynamics (Natcher et al. 2005; Westley et al., 2006). In the Great Lakes regime, those relationships themselves are complex, including those between the public and their governments (including subnational governments), between governmental agencies and the IJC, among the IJC and the research community, industrial sectors, and civil society organizations— but also between intentions and outcomes, between science and policy, action and reflection, and among information and knowledge. The relationships are dysfunctional in that they can be at cross purposes or absent altogether. To this end, I argue that Great Lakes governance should be process driven, particularly where those processes create opportunities for reflective learning and adaptive action, and should operationalize these characteristics, accommodate social and political contexts, and allow for diversity and experimentation.

On the Evolution of the Great Lakes Water Quality Agreement

Adaptive governance will involve an "evolution of new governance institutions capable of generating long-term, sustainable policy solutions to wicked problems through coordinated efforts involving previously independent systems of users, knowledge, authorities, and organized interests" (Scholz and Stiftel, 2005). Evolution operates most forcefully when feedback loops are tight, occurring most naturally when individuals interact primarily with a small subset of the universe and realize the costs and benefits of their actions on realistic time scales (Levin, 1999). I am drawn to how this description of evolution alludes to key elements of place-based, participatory restoration through processes such as RAPs that are significantly and comprehensively social in nature. In mapping those key elements onto the description of evolution, the individuals are stakeholders, some with inclinations for leadership, the subsets are localized environ-

ments, and the benefits often intangible. The feedback loops permit learning, once it is determined what learning is required. Time scales can complicate learning, however, where political cycles are short relative to the time frame required to measure the responses of biotic communities. Governance processes must therefore foster a reconciliation of those cycles.

Adaptive governance would represent a dramatic evolution in the Great Lakes regime requiring a reinvestment in leadership and accountability—to invite innovation and experimentation in policy and management that makes learning a meaningful outcome, and to make reporting on learning a form of accountability that embraces evaluative feedbacks better able to track trends and emergence and innovation (Westley et al., 2006). The complexity and deficits involved in Great Lakes governance present an institutional conundrum that hampers progress, particularly in the roles and responsibilities of the IJC, the BEC, and the SOLEC. This could be addressed by an institutionalization of adaptive governance. The IJC has demonstrated forward-thinking and independence in the past, and is long-established within the Great Lakes institutional framework. Within that framework, the IJC is well suited to foster "epistemic cognition"— a form of reflective judgment that considers the limits of knowledge, the certainty of knowledge, and the criteria for knowing, and that leads to deeper interpretations of the nature of a problem and definitions of limits to solving it (Kitchener, 1983). For the same reasons that the third-party function of the IJC has been lauded and effective in the past, the IJC (and its substructures) could be reinvested with the capacity to explore, guide, and operationalize adaptive governance as illustrated in Figure 9. I emphasized in Chapter One that the purpose of the governments, as described in Article II of the Agreement, requires that they make "maximum effort to develop *programs, practices* and technology *necessary for a better understanding* of the Great Lakes Basin Ecosystem" [my emphasis]. Institutional roles and responsibilities in adaptive governance would also evolve under Article VII of the Agreement that deals with the powers, responsibilities, and functions of the IJC. Much of Article VII is outdated because it describes roles and functions that are no longer relevant (e.g., Section 1(a) on data concerning water quality is now the responsibility of SOLEC, and Section 1(b) on data concerning the General and Specific objectives of the Agreement is no longer performed by the IJC). Importantly, Section 1(c) concerns "boundary waters" to the exclusion of the nearshore. Article VII could include explicitly how adaptive governance could function if institutionalized—a process that could likewise help to determine how the functions of BEC and the SOLEC could best contribute to adaptive governance.

Adaptive governance is operationalized through social capital, networks, leadership, and trust (Folke et al., 2003). I believe that fostering these qualities in the processes of a renewed Agreement starts with a recognition that authority can both enable and constrain, and be shared without being relinquished. Reinvented Great Lakes governance must innovate and sus-

tain more engaging and responsive processes for adaptive problem solving, and foster greater capacity for adaptive leadership within the cultures of Great Lakes institutions. I hope and suspect that this research will be of broad interest, if only because so many people are struggling— in circumstances not unlike those in Great Lakes AOCs—to design successful collective action for restoring degraded environments. Some of those people will have an natural inclination towards adaptive problem solving. Perhaps a few of them will rise through the ranks of management agencies, likely against a strong belief among their colleagues that they are subversive in their tolerance of uncertainty and promotion of risk taking. Perhaps a few others will struggle in agency outposts to obtain funding for experimental management, and still others (such as citizens and CEOs) will voluntarily make adaptive problem solving representative of broad interests and reflective of a deeper, collective knowledge. Each of them will have the capacity for leadership in their unique roles, and will combine their courage and talents to manage for complexity. Westley (2002) profiled such individuals as having the capacity to manage *through* (with a sustained commitment to a scientific approach to management), to manage *out* (with a commitment to include and mediate diverse groups in society), to manage *in* (by building and maintaining internal support for ongoing learning within their own organization), and to manage *up* (by being always mindful of the larger political context in which their own problem solving is embedded). Ultimately, this research has been for their benefit.

Literature Cited

Argyris C, Schön D. 1978. Organizational Learning: A Theory of Action Perspective. Addison-Wesley.

Argyris C, Schön D. 1996. Organizational Learning II: Theory, Method, and Practice. Addison-Wesley.

Bartunek JM, Austin JR, Seo M-G. 2008. Conceptual underpinnings of intervening in organizations. In: Handbook of Organizational Development. Cummings TG, editor. pp. 151-166. Sage.

Benjamin AS, Stelmach G, Guadagnoli M, de Belle JS, Etnyre B, Polk T, editors. 2008. Human Learning: Biology, Brain, and Neuroscience. Elsevier.

Canada and the United States. 2009. State of the Great Lakes 2009. State of the Lakes Ecosystem Conference, prepared by Environment Canada and the U.S. Environmental Protection Agency.

Clark RN, Stankey GH, Kruger LE. 1999. From new perspectives to ecosystem management: a social science perspective on forest management. In: Ecosystem Management: Adaptive Strategies for Natural Resources Organizations in the Twenty-First Century. Aley J, Burch WR, Conover B, Field D, editors. pp. 73-84. Taylor and Francis.

Dawe NK, Ryan KL. 2003. The faulty three-legged-stool model of sustainable development. Conservation Biology, 17: 1458-1460.

Flood RL. 1999. Rethinking the Fifth Discipline: Learning Within the Unknowable. Routledge.

Folke C, Colding J, Berkes F. 2003. Synthesis: building resilience and adaptive capacity in social-ecological systems. In: Navigating social-ecological systems: building resilience for complexity and change. Berkes F, Colding J, Folke C, editors. pp. 352-387. Cambridge University Press.

Folke C, Hahn T, Olsson P, Norberg J. 2005. Adaptive governance of social-ecological systems. Annual Review of Environment and Resources, 30: 441-473.

Hackman JR, Edmondson AC. 2008. Groups as agents of change. In: Handbook of Organizational Development. Cummings TG, editor. pp. 167-186. Sage.

Hartig JH, Zarull MA. 1992. Keystones for success. In: Under RAPs: Toward Grassroots Ecological Democracy in the Great Lakes Basin. Hartig JH, Zarull MA, editors. pp. 263-279. University of Michigan Press.

Hilborn R. 1987. Living with uncertainty in resource management. North American Journal of Fisheries Management, 7: 1-5.

Levin S. 1999. Fragile Dominion: Complexity and the Commons. Perseus Books.

Levitt B, March JG. 1988. Organizational learning. Annual Review of Sociology, 14: 319-340.

Linton J. 2010. What Is Water? The History of a Modern Abstraction. UBC Press.

MacDonagh-Dumler J. 2009. Policy innovation for Great Lakes ecosystem management. Journal of Great Lakes Research, 35: 477-481.

March JG. 2008. Learning and the theory of the firm. In: Explorations in Organizations. March JG, editor. pp. 79-95. Stanford Business Books.

Milbrath LW. 1988. A governance structure designed to learn would better protect the Great Lakes system. In: Perspectives on Ecosystem Management for the Great Lakes. Caldwell LK, editor. pp. 141-167.

Miller A. 1999. Environmental Problem Solving: Psychosocial Barriers to Adaptive Change. Springer.

Moran EF. 2010. Environmental Social Science: Human-Environment Interactions and Sustainability. Wiley-Blackwell.

OED [Oxford English Dictionary]. 2010. Oxford English Dictionary, Online edition. Oxford University Press.

Parson EA, Clark WC. 1995. Sustainable development as social learning: theoretical perspectives and practical challenges for the design of a research program. In: Barriers and Bridges to the Renewal of Ecosystems and Institutions. Gunderson LH, Holling CS, Light SS, editors. pp. 428-60. Columbia University Press.

Regier HA, Jones ML, Addis J, Donahue M. 1999. Great Lakes–St. Lawrence River basin assessments. In: Bioregional Assessments: Science at the Crossroads of Management and Policy. Johnson KN, Swanson FJ, Herring M, Greene S, editors. pp. 133-165. Island Press.

Senge P. 1990. The Fifth Discipline: The Art and Practice of the Learning Organization. Double-day.

Sproule-Jones M. 2002. Restoration of the Great Lakes: Promises, Practices, Performances. University of British Columbia Press.

Stafford Smith DM, McKeon GM, Watson IW, Henry BK, Stone GS, Hall WB, Howden SM. Learning from episodes of degradation and recovery in variable Australian rangelands. Proceedings of the National Academy of Science, 104: 20690–20695.

Stoker G. 1998. Governance as theory: five propositions. International Social Science Journal, 155: 17-28.

Susskind L, Field P, van der Wansem M, Peyser J. 2007. Integrating scientific information, stakeholder interests, and political concerns. In: Integrated Resource and Environmental Management: Concepts and Practice. Hanna KS, Slocombe DS, editors. pp. 181-203. Oxford University Press.

Westley F. 1995. Governing design: the management of social systems and ecosystems management. In: Barriers and Bridges to the Renewal of Ecosystems and Institutions. Gunderson LH, Holling CS, Light SS, editors. pp. 391-427. Columbia University Press.

Westley F. 2002. The devil is in the dynamics: adaptive management on the front lines. In: Panarchy: Understanding Transformations in Human and Natural Systems. Gunderson LH, Holling CS, editors. pp. 333-360. Island Press.

Westley F, Zimmerman B, Patton MQ. 2006. Getting to Maybe: How the World is Changed. Random House Canada.

CONCLUSIONS AND RECOMMENDATIONS

The research in this thesis has been largely exploratory. Exploration is usually driven by questions. There are several questions that I have attempted to address with this research and that I believe are central to helping think about where the evolution towards adaptive Great Lakes governance should go next.

- What characteristics define leadership and various forms of social and policy learning in the existing Great Lakes institutional regime?

- To what degree are the elements of adaptive governance already present in the Great Lakes? Where is the potential for their enhancement? What are the limitations?

- What deliberative institutional processes could be improved or designed to facilitate the necessary leadership and learning among Great Lakes agencies and stakeholders?

- What current or future programs or projects would be amenable to and benefit from such deliberative institutional processes? What are the most feasible opportunities to begin to advance changes in governance that would embody the policy and management appraisals, adaptive and decision principles, and governance options detailed in this thesis?

- What further lessons could we take from decades of effort to restore the Great Lakes?

Conclusions

This thesis has examined deficiencies in the institutional processes and characteristic attitudes of Great Lakes governance, designed policy options intended to remedy those deficiencies, and conceived of a framework for reconceptualizing an adaptive approach to restoration. The thesis contributes new knowledge and perspective to our understanding of and progress towards enhancing participatory processes, social learning, and leadership for adaptive Great Lakes governance. In meeting the objectives for this study, the thesis has begun to provide answers to the questions above. In conclusion, the initial conditions for continuing this exploration include that:

- the purpose of the Agreement indicates that a better understanding (i.e., learning) of the Great Lakes system, including humans aspects of that system, is an intended outcome of implementation of the Agreement;

- perfect implementation of policy cannot be achieved, and that better institutional arrangement are required to reconcile deficits in implementation and the tendency for implementation to lack adequate coordination and priority;

- stakeholder incentives and learning processes are undermined by pathologies in management that include a lack of responsiveness and analysis, a lack of program auditing that links performance with learning outcomes, a lack of appropriate personalities in key roles, and multiple and incompatible programming;

- learning processes that provide continuous feedback mechanisms for interpretation, evaluation, and reform of policy and management are required;

- the tools for advancing such learning processes that treat and reduce uncertainty and that more effectively engage public audience and stakeholder participants are available, and that criteria and expert guidance for their implementation are available;

- the principal institutional limitations of the Remedial Action Plan program—the signature aspect of the Agreement to embody the ecosystem approach—are both structural and attitudinal in nature, and related to the inattentiveness in authority and program coordination;

- strengths of RAPs included inclusive decision making opportunities, administrative support provided for stakeholder groups, and the cohesive progress that was made in cases where appropriate leadership was available;

- adequate funding has been a major limiting factor in Great Lakes restoration success;

- the authority, capacity, and effectiveness of the IJC and numerous governmental elements of the regime have waned significantly as the regime has evolved since the 1987 Protocol;

- a ranking of possible RAP policy remedies by a broad array of stakeholders with significant direct RAP experience indicated a consensus that the remedies were relatively feasible and likely to succeed as enhancements to the current governance of RAPs;

- the challenges to achieving adaptive governance in the Great Lakes involve obstacles that are significantly more psychosocial than technical in nature.

Recommendations

Adaptive governance suggests that policies and procedures should incorporate explicit learning objectives. Learning objectives are meant to capture what should be newly understood from action and form the basis for an evaluation of performance. This task is exceptionally difficult for individual organizations, requiring a remodelling of roles and responsibilities that facilitates the desired learning. It follows that there would be significantly more difficulty in designing an adaptive governance regime for regional restoration of the Great Lakes based on a model such as Figure 9. With that in mind, the following recommendations suggest a course of action towards a better understanding of the characteristics of current Great Lakes governance and steps that could increase its adaptive capacity.

1. The IJC has been celebrated as a highly effective mechanism for investigating and resolving transboundary water issues. The challenges to achieving adaptive governance in the Great

Lakes require a vigorous and independent forum in order to discover adequate and appropriate strategies. For this purpose, the IJC could establish an Adaptive Governance Task Force. The federal governments could issue a reference to the IJC under the Great Lakes Water Quality Agreement in order to facilitate and adequately support such a Task Force. (It is recognized that this could be considered a role for the Great Lakes Water Quality Board or Science Advisory Board. Such a role for these boards is presumed to possibly undermine their ability to accomplish any other business, so great could be the task, and this is therefore judged to require a stand alone panel of inquiry. This is not to say that members of the WQB or the SAB could not serve on such a Task Force.) A reference of this kind would emphasize the priority placed by the governments on revitalizing Great Lakes governance and best link the terms of the reference to recommendations and implementation. The Task Force could

A. be comprised of broad expertise and direct experience with theory and practice in organizational development and in the social, behavioural, natural, and physical sciences in order to investigate an evolution to adaptive governance of the Great Lakes;

B. investigate and characterize Great Lakes governance with respect to the conceptual framework proposed in this thesis and other methods of evaluating institutional effectiveness; and

C. strategize regarding opportunities for the regime to engage the conceptual framework in Figure 9.

2. Such a Task Force and its findings and recommendations could remain a theoretical exercise, however, unless the principles and techniques of adaptive governance are embraced and accepted broadly among stakeholders in the Great Lakes regime. To influence and facilitate that understanding and acceptance of adaptive governance, agencies, organizations, and other stakeholders could:

A. examine techniques and opportunities to produce organizational cultures supportive of adaptive problem-solving based on process characteristics that foster social learning: open communication, diverse participation, unrestrained thinking, constructive conflict, democratic structure, multiple sources of knowledge, extended engagement, and facilitation (Schuler et al., 2003);

B. develop and use a variety of modes of communication, processes of group deliberation, and scenario-planning and visioning exercises to deal with complexity;

C. foster those individual leaders capable of championing social and policy learning processes and adaptive modes of problem-solving; and

D. foster flexible self-organizing adaptive problem-solving networks.

Literature Cited

Schuler TM, Decker DJ, Pfeffer MJ. 2003. Social learning for collaborative natural resource management. Society & Natural Resources, 15: 309-26.